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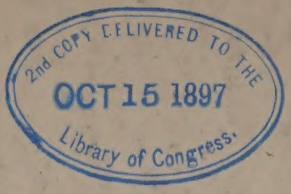

THE

PRACTICE OF SURGERY

A TREATISE ON SURGERY FOR THE USE OF PRACTITIONERS AND STUDENTS

BY

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PREFACE.

THE object aimed at by the authors of this book has been eminently practical. They recognize the fact that to give a synopsis of the science of surgery in one volume becomes each year a more difficult task, owing to the extension of the field of surgery since the adoption of aseptic methods. It appeared, however, feasible to condense within that limit the information necessary to enable the general practitioner or the student to carry on or begin the successful practice of the art of surgery. It seemed to them that the essential information included (1) a description of the various injuries and surgical diseases sufficiently full to enable the practitioner to recognize them when met with in practical work. (2) Full directions for the treatment of such injuries and diseases as would usually be attended by the general practitioner. (3) A sketch of the treatment of the more difficult conditions, such as would allow the practitioner to advise patients intelligently in obtaining special skilled surgical attention. (4) An outline of the accepted facts and theories of the etiology and pathology of the various surgical affections sufficient to form a foundation for the clinical picture and give directions for the treatment. Even with these limitations the material is so bulky as to require great condensation and the most careful choice of those subjects which were to receive detailed treatment. The authors cannot hope that all their critics will agree with them in the decision of the relative proportions assigned to the various topics, but they trust that the practical conclusions will be found conservative and yet thoroughly modern. They hope that the book will prove a useful guide to the student in the beginning of his work in the complicated science of surgery, and that it may also serve as a ready help in the solution of the surgical problems which confront the busy general practitioner.

The authors jointly endorse the practical conclusions throughout the book, but it may be of interest to know that the senior author prepared the chapters on Diseases of the Bones and Joints, Fractures and Dislocations, the Blood-Vessels, the Chest, the Rectum, Minor and Orthopædic Surgery, Amputations, etc., while those on Bacteriology, Inflammation, the Head,

the Breast, the Abdomen, the Urinary Organs, and the Male and Female Genitals, etc., were written by the junior author. The chapter on the Injuries and Diseases of the Eye was prepared by Professor George E. de Schweinitz, whose masterly treatment of the subject cannot fail to commend it to the judicious reader.

The majority of the illustrations used are original and were made from photographs or drawings. When illustrations have been taken from other sources, the authors have, where it was possible, credited the source from which they were taken.

The authors desire to express their thanks to Dr. Timothy Matlack Cheesman, Chief of the Department of Bacteriology in the College of Physicians and Surgeons, Columbia University, New York, for valuable assistance in the preparation of some of the illustrations of bacteria, and to Dr. Francis Carter Wood, late House Surgeon to St. Luke's Hospital, of New York, for drawings of bacteriological and histological subjects. They also desire to express their thanks to Dr. J. H. Jopson, of Philadelphia, for careful revision of the proof-sheets, to Mr. James Wood for excellent photographic work used in illustrating many of the subjects, and to Mr. Joseph McCreery for his careful and critical proof-reading.

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THE

PRACTICE OF SURGERY.

CHAPTER I.

SURGICAL BACTERIOLOGY.

A MICRO-ORGANISM, or microbe, is a minute plant or animal—too small, as a rule, to be visible to the unassisted eye. The word germ may be used to designate any micro-organism which is the cause of disease, but it has so many other meanings and has been so loosely employed even in this sense that it cannot be used for accurate scientific description. Bacteria are minute plants of the order of fungi, many of which are able to produce fermentation, decomposition, or disease. Although the word bacterium by derivation has the same meaning as bacillus, and indicates a rod-shaped fungus, it has been so loosely employed that it may very well be applied to the entire family, retaining the term bacillus in the narrower sense.

Very few of the unicellular *animal* micro-organisms, usually called protozoa, have been proved to cause disease, and the only important ones thus far discovered are the malarial germs of Laveran, the dysenteric amœba of Koch and Kartulis, which is also said to cause abscesses of the liver, and, finally, the supposed "parasites" (sporozoa, psorospermiæ, or coccidia) of malignant tumors, the real nature of which is still uncertain.

The *vegetable* micro-organisms which are surgically important are the schizomycetes or bacteria, the saccharomycetes or yeast plants, and the actinomyces or ray-fungus. The last-named appears to be a mould-fungus rather than a bacterium, although its exact relations are not yet settled, and, as it is the only one of its kind, we refer for its description to the section on the disease caused by it, called actinomycosis. The saccharomycetes are of little surgical interest.

Description of Bacteria.—The schizomycetes, however, include all the bacteria of putrefaction and disease, the former being called *saprophytic* and the latter *pathogenic* bacteria. They are minute fungi, each consisting of a single cell, enclosed in a cell-membrane of cellulose, that can be demonstrated by iodine, which causes the protoplasm to retract from the cell-wall. There is no nucleus. Some of the bacteria are colorless, others pigmented —yellow, blue, or red. The cells vary in shape and size in the different species, as well as in their mode of growth, and are named in accordance with these peculiarities. The round or oval cells are called cocci; the rod-shaped organisms, bacilli. The cocci are called micrococci or macrococci,

according to their size; diplococci or tetracocci, according to the production of pairs or groups of four in their multiplication; and, finally, certain species are called streptococci, because in their growth they always form chains of cells, while others are known as staphylococci, because they grow in irregular clusters resembling bunches of grapes. Some of the bacteria have the power of motion, generally produced by cilia or flagella (Plate II., Fig. 8), and some are motionless.

Habitat.—The air, the water, the ground, our clothing, our food, even our own bodies, and almost everything about us, are covered by or impregnated with these omnipresent micro-organisms, among which pathogenic germs may be found. Every species has its particular habitat, where the conditions especially favor its growth, just as any of the larger plants requires to be suited in the soil, the supply of water, the temperature, and the proper amount of light in order to make its growth and multiplication possible. The bacteria in the air are more numerous in dry weather, being carried up as dust by the wind, for a moist surface holds any bacteria which may lie upon it. So complete is the action of moisture that air which contains six hundred micro-organisms when inspired has been shown to return from the lung with almost none, the moist respiratory surfaces catching the bacteria, so that the expired air is practically sterilized; and this is true even when it comes from diseased lungs. The act of coughing, however, may expel bacteria in the mucus ejected. The number of bacteria in the air is very variable, but it is greater in houses than out of doors, and is naturally increased by attempts to clean the rooms, the air in a hospital being found to contain from forty to eighty microbes in ten litres immediately after sweeping, and several hours later only from four to ten microbes in the same quantity. In Billroth's clinic-room the air contained most germs just after the students had left, stirring the dust with their feet. Durante found that the air contained the greatest number of microbes at a level of about a yard above the border of the beds in a hospital ward, while close to the floor it was almost sterile. The bacteria which are found in the air, however, belong chiefly to the innocent varieties, and the danger of infection of wounds from this source is very slight. There has been much dispute as to the presence of bacteria in healthy human blood, and it has finally been settled that in perfect health it contains no bacteria. But if we consider how small a wound or ulcer will allow the entrance of the pyogenic germs, and that this lesion may be concealed in the mouth, rectum, or elsewhere in the interior of the body, it will readily be seen that many persons who appear to be in perfect health may have bacteria circulating in the blood, ready to implant themselves in any bone or other part of the body the vitality of which may be impaired.

Parasitic Nature.—The number of species of pathogenic germs is comparatively small compared with the total number of all the varieties of germs, for the latter are practically innumerable; and it is simply by reason of this fact, and the power which the animal tissues have of resisting the fungi, that wounds left without care and protection sometimes heal by primary union, and that any animals are able to exist. The schizomycetes are unable to extract nitrogen from the air or the soil like the higher vege-

tables, and must, therefore, be provided with the higher nitrogenous compounds, such as are produced by vegetable and animal life. Some of them are able to live upon dead organic matter, while others cannot exist without living tissues to feed upon, and are, therefore, true parasites. There are some which are able to live either on dead or on living tissues, and they are known as *facultative* parasites, a class which includes the majority of pathogenic germs.

Effect of Oxygen.—The germs require carbon and water as well as nitrogen, and some also need free oxygen, but to others this is not absolutely necessary, and there are some which cannot grow in the presence of free oxygen. Those which require oxygen are called *aërobic;* those which do not, *anaërobic;* and the intermediate class, including most of the pathogenic varieties, are called *facultative anaërobic*, as they grow either with or without oxygen. Bacteria are very sensitive to temperature, few being able to live below 68° F. (20° C.) or above 104° F. (40° C.), and the pathogenic varieties thrive best at about the normal temperature of the blood. Direct sunlight retards their growth, and may kill them.

Growth. Spores.—Bacteria multiply by division, each cell dividing into two, which then grow as separate individuals, although they may remain connected in chains or clumps. A number of cells together sometimes throw out a gelatinous material which binds them into one mass, called a *zooglœa.* Some of the bacteria also grow by the production of spores, which are endogenic or arthrogenic.

The *endogenic* spores appear as minute round or oval bodies in the centre or at one end of the bacillus, which is usually distended by the growth of the spore. The parent dies, and the spore is set free. Under favorable conditions the latter will germinate, but if the proper soil or food and temperature are not at hand, it remains quiescent, like the seed of a plant, waiting, it may be for years, until proper conditions are present. The spores have such a thick envelope and such great vitality that it is much more difficult to kill them than the developed cell, a temperature of 212° F. (100° C.) moist heat being required to destroy the spores of anthrax, for instance, whereas 130° F. (55° C.) will kill the bacillus.

The *arthrospores* are not so resistant. The cocci never produce endogenic spores, but are limited to the arthrospores, while the latter are rarer in the bacilli. But little is known of the arthrospores, and they appear to be simply larger and more resistant than the ordinary individual cocci. The growth of spores is a sign of deterioration of the bacteria, for, while other fungi produce spores under any conditions, the bacteria grow by division so long as the conditions are favorable; and it is only when a lack of food-material, a change in temperature, or an accumulation of their own poisonous products threatens them with extinction that the more resisting form, the spore, is produced.

Toxines.—As bacteria grow, certain poisonous chemical substances appear about them, either produced by them directly, like the excretory matters of other plants, or formed in the organic matter or tissues in which they live as a result of their presence. Some of these substances are alkaloidal, and are known as ferments or *ptomaines*, while others are albuminous

in nature, and are called *toxalbumins*. The word toxine is employed by some writers as equivalent to ptomaines, and by others as synonymous with toxalbumins. The ptomaines and toxalbumins are exceedingly powerful poisons, producing local necrosis, inflammation, and even suppuration, when introduced by themselves, and entirely free from living germs, into the tissues of animals. The local and general symptoms of this intoxication depend upon the particular toxine employed, and a large number of these poisons have been isolated and studied. Those of the surgically important pathogenic germs produce inflammation locally, with general symptoms of fever, chills, cardiac depression, irritation of the kidneys and bowels, and cerebral symptoms, such as delirium or coma. The toxalbumins also appear to have the effect of destroying the bacteria to which they owe their origin when they have been produced in sufficiently large quantities.

Cultivation.—Bacteria are cultivated for study in the laboratory in meat extracts, in gelatin or agar-agar (a sort of vegetable gelatin), on raw potato, in blood-serum, and in other materials. While some species grow readily in all these media, others are exceedingly difficult to cultivate, especially those which require the exclusion of oxygen. Temperature is a very important factor in their cultivation, and most varieties require a temperature of 86° to 95° F. (30° to 35° C.) in order to flourish. The simplest method of cultivation is in bouillon, sterilized in flasks with cotton plugs. (Plate I., Fig. 1.) The bouillon is inoculated with a sterilized needle or loop of platinum wire, which is made to pick up a minute quantity of the substance to be cultivated, and is then dipped in the bouillon, and the flask well shaken in order to distribute the material. The flask is placed in an oven where an even temperature of the proper grade is maintained by a thermostat, and the growth of the bacteria is shown by a cloudiness appearing in the bouillon. Gelatin and agar-agar are used in test-tubes or on flat glass saucers. They may be simply melted and allowed to solidify in the test-tube, usually placed at an angle so as to increase the extent of surface available for inoculation. Esmarch's method of "roll culture" consists in quickly cooling the gelatin by placing the tube, protected with a rubber cap, in cold water, or in a groove on a block of ice, while a rapid rotation is kept up in order to spread the gelatin over the inner surface of the tube in a thin layer. When gelatin or agar is used in the saucers, or Petri's dishes, known as *plate-cultures* (Koch), it is simply melted and poured into the shallow saucer so as to form a very thin layer, and protected with a glass cover. The agar can be sterilized by steam for any necessary time, but this would decompose the gelatin; therefore the latter must be sterilized by the "fractional" method, which will be described below. When potato is employed, it is cut up with a sterilized knife, sterilized by the fractional method, and the cut surface used for cultivation. In all these last-mentioned methods the mode of inoculation or *sowing* is the same; the material to be *sown* is picked up with the sterilized needle, and the latter is then thrust into the media to be inoculated, making a *stab-culture*, or is drawn over the surface. Gelatin-cultures may also be made by melting the gelatin, inoculating it like bouillon, and disseminating the

germs by shaking before it hardens. The culture media must be kept from all contact with the air by using cotton plugs, or some sort of cover, and by the greatest precautions during the necessary exposure in sowing. The growth of bacteria is very rapid, one individual being capable of producing over sixteen million within twenty-four hours (Cohn).

The different varieties of bacteria are recognized by the way in which they grow in the media, by the shape and color of the *colonies* (as the small masses which they form are called), and by their power of liquefying the gelatin and other chemical reactions. A *pure culture* is one in which only a single species of bacteria exists. It can be obtained by making a very long series of bouillon-cultures, but far better by the method introduced by Koch of using solid media for cultures. If a *plate-culture* is made, as the needle is lightly drawn over the surface of the gelatin it spreads the material to be "sown" all along the line. The various bacteria will be present in varying quantity at different parts of the line, and in a few hours the different colonies can be recognized with a magnifying-glass. The one which is most like the particular germ sought is then touched with the needle, and another plate sown in the same manner with this colony. This second culture will naturally contain a larger proportion of the bacteria desired, and after several repetitions of this process a plate will finally be obtained which will contain only the one species desired.

Anaërobic germs are cultivated in the deeper parts of the solid media, or by covering the surface with a thin sheet of mica, which is sealed to the tube with paraffin, or by maintaining an atmosphere of pure hydrogen gas around the culture.

Inoculation.—Another method of studying bacteria is by inoculation in animals. Either the original material or a pure culture obtained from it is introduced. The material inoculated may be injected under the skin or into a vein, or inserted into the anterior chamber of the eye, or into the peritoneal cavity, according to the effect it is desired to produce or the germ to be studied. If the lesions produced are the same as those of the original disease, we obtain a proof in this manner of the causal relation between the germ and the disease. The effects of the toxines can also be studied by these means.

Infection.—Bacteria gain admission to the living tissues of animals under natural conditions by penetrating any of the mucous membranes which they can reach or by entering open wounds. Some of the pyogenic varieties can be made to infect the sebaceous ducts and the hair-follicles by being vigorously rubbed into the skin, or even by being kept long in contact with it in a moist dressing; but this mode of infection is probably rare in nature. It may be said in general that an intact epidermis is almost a complete protection against infection, and that an intact mucous membrane is a good protection. This difference in vulnerability between the mucous membranes and the skin is important, and is probably due to the cornification of the epidermal cells and to their numerous layers, as well as to the protection afforded by the thick corium, the single layer of soft mucous cells being much more easily penetrated and having no strong basement membrane beneath it.

When bacteria have entered the circulation they collect and grow in any organ or part of the body in which the blood-current is retarded or in which the vitality of the tissues is impaired by injury or otherwise. A slight injury appears to be more apt to provoke their colonization than a severe one, a fracture being less likely to result in osteomyelitis under such circumstances than a contusion of the bone, and it is supposed that the severer injuries excite so strong a reparative reaction that the tissues are more ready to resist the bacteria than when they have not been so thoroughly aroused. Such an injured place is called a *locus minoris resistentiæ*, a weak place in the defences of the body. It has been found that the circulation of ptomaines or toxines in the blood weakens the natural resistance of the tissues, and parts which were previously able to resist infection yield to it when these are present, a fact which is a strong argument against making fresh wounds when suppuration is present elsewhere, and an argument also for the speedy evacuation of pus in any case. Bacteria may enter the body of a fœtus through the placental circulation, the animal being born infected with germs which had been present in the mother's circulation, an hereditary transmission of germs which has been observed in erysipelas, tuberculosis, anthrax, and malignant œdema.

Elimination.—When bacteria are circulating in the blood they can be eliminated in various ways. The kidney is the organ which most frequently throws them out, the bacteria of typhoid fever, septicæmia, and pyæmia having been actually observed in the urine. This process generally involves the infection of the kidney itself by the microbe in question, but some cases of pyæmia are on record in which the bacteria were excreted by the kidney without the development of any abscesses in that organ. The bacteria may also be eliminated with the bile (*B. typhosus*, *B. coli*, *B. anthracis*, and the pyogenic cocci) or thrown out by the intestinal mucous membrane. The salivary glands have been observed to excrete the germs with the saliva, and it is supposed that this circumstance partly explains the frequency of metastatic abscesses in those organs. The bacteria of puerperal septicæmia and of typhoid fever and tuberculosis have been found in the milk of nursing mothers, proving that the mamma may also take part in this purification of the blood. It is supposed that the sweat-glands also eliminate both bacterial toxines and the bacteria themselves.

Effect on the Body.—The introduction of living bacteria into the tissues is followed in most cases by the local phenomena of inflammation, and later by general symptoms of poisoning caused by the entrance into the circulation of the living bacteria or the ptomaines or toxines produced by their growth. The symptoms depend upon the particular variety introduced. The saprophytic bacteria (those of decomposition) cannot live unless dead tissue, blood, or purulent fluids be present, and cannot survive in the circulation, but if they find material in the body to live upon, their poisonous ptomaines can be absorbed and cause dangerous symptoms. The majority of the disease-producing germs cause local inflammations, and the pyogenic varieties cause the production of pus. Some, however, excite very little or no local reaction, but enter the circulation at once. These various phenomena will be studied at length under the head of inflammation. It would

seem as if the constitutional danger to be feared from any pyogenic germ were in inverse proportion to the amount of inflammation it excited, the local inflammatory changes appearing to limit the growth of the invading bacteria and to prevent their entrance or the entrance of their toxines into the circulation.

Resistance offered by the Tissues.—The tissues have considerable powers of resistance to infection under ordinary circumstances, although the exact sources of this power are not well understood. Phagocytosis, which is the power of destruction and removal of bacteria supposed to be possessed by the leucocytes emigrating from the blood-vessels (as will be described in the chapter on inflammation), explains it in part, but the majority of pathologists are unwilling to give this mode of action the full credit which Cohnheim and Metchnikoff claim for it. It is also partly accounted for by the germicidal properties of blood-serum, which can be compared to that property of the serum by which it dissolves the blood-corpuscles of another animal, as shown by Landois years ago. It has been found that if the serum is gently heated to 131° F. (55° C.) it loses the power of destroying corpuscles and germs, which proves that their destruction is not due merely to the specific gravity of the serum or to its proportion of inorganic salts, for neither is altered by the heat. It has also been shown (Buchner) that this power is destroyed by adding distilled water to the serum, although it remains intact when the serum is diluted with physiological salt solution (one part sodium chloride to five hundred parts water), and can be restored to the serum diluted with plain water by the addition of a sufficient quantity of sodium chloride. Certain experiments (Roger) indicate that there must be some difference between the two actions of the serum in dissolving corpuscles and destroying germs, for it appears that the streptococcus of erysipelas grows as well in the serum of immunized as of normal animals, but that it loses its virulence in the former. These facts make it certain that the germicidal power resides in some proteid body analogous to the antitoxines, to be described below. The resistance of the tissues may in some cases be due to the absence from them of some particular element necessary to the growth of a particular micro-organism. This refractoriness varies in every species of animal in its relation to every form of germ, and different individuals of one species also vary in their susceptibility, and even different parts of the body vary in the same individual. Thus, inoculations of cultures of a certain strength will produce suppuration in the eye but not in the cellular tissue, while stronger ones will act in the latter but not in the peritoneum. The resistance of the human tissues to the pyogenic germs is usually less than that of the lower animals. Any cause which depresses the system, such as exhausting disease, anæmia, diabetes mellitus, arterio-sclerosis, alcoholism, obesity, hunger, fatigue, and even exposure to cold, is apt to favor the growth of germs, although experiments have as yet failed to prove the influence of exposure.

The variations which are found in the virulence of the bacteria concerned must also be taken into account. Esmarch showed that some spores of anthrax were killed in one minute by exposure to steam, while others survived up to twelve minutes, and Welch observed one specimen of

staphylococcus which would cause suppuration and death from septicæmia in twenty-four hours, while fifteen times the amount of another specimen, which was apparently identical in other respects, failed to produce any effect either locally or generally. These variations in virulence occur both in natural and in artificial cultures of the germs, although much more marked in the former, and often without any assignable reason. Probably in some cases the result is to be explained by the confusion of various species of bacteria, but the majority must be due to variations of one species caused by differences in the soil in which they grew or by some other external influences. The occurrence of more than one species of bacteria in a culture sometimes increases and sometimes diminishes the virulence of their effect, according as the two encourage or retard each other's growth, just as is seen when two of the higher plants are sown in one field. The pneumococcus is antagonistic to the bacillus anthracis, as is also the streptococcus of erysipelas. The virulence of diphtheria is increased by the presence of the streptococcus, and the latter is more virulent when accompanied by B. coli or B. prodigiosus. It has also been proved that the soil in which the inoculation takes place is of prime importance for its success. The presence of dead or injured tissue at the place of inoculation favors germ-growth. Bacterial growth is favored by the presence of blood-clot or foreign substances, and, above all, by some of the substances in which the germ has already been growing at the time of its inoculation and containing some of its toxines. Thus, a certain amount of pyogenic germs may be introduced into the peritoneal cavity without effect, and sterilized potato can also be inserted without exciting inflammation; but if the two are introduced together, the bacteria multiply at once in the potato and then easily invade the organism from that base of supply or storehouse of energy. In regard to blood-clot, it is necessary to alter somewhat the older views in regard to its favoring the infection of wounds, for recent clinical experience shows that even suppurating wounds can be made to heal with primary union by the method of filling their cavities with blood and closing the wounds without drainage; and it has been shown that under such circumstances, as well as in the coagulated blood used in laboratory experiments, the pyogenic germs remained alive, but did not multiply. This arrest of development may be due to the germicidal or germ-inhibiting powers of the serum, and very likely depends upon a limitation in the quantity of germs. It certainly depends upon freedom from the bacteria of putrefaction, for decomposing blood is one of the most infectious of substances.

Immunity.—An animal which is able to resist the invasion of any species of bacteria is said to be refractory to or immune against that variety of germ. In many cases this immunity is constant in certain animals for certain bacteria: thus, gonorrhœa and syphilis cannot be transmitted to the lower animals, and man is refractory to the virus of mouse-septicæmia and many other diseases. In many infectious diseases one attack protects an individual for a lifetime, and one form of disease may even protect in future from another and more virulent form, as vaccination protects against smallpox. Pasteur supposed that the bacteria in their growth exhausted from the body some material necessary for their existence, so that none subse-

quently inoculated could thrive. By others this protection is supposed to be due to the production of certain substances by the bacterial growth which remain in the body and render it immune against that particular form of infection. In favor of the latter theory is the fact that if the serum of an animal which has been rendered immune against a certain bacterium be injected into another susceptible animal, the same immunity can be temporarily reproduced in the second animal. The exact nature of these immunizing substances is uncertain, but it is supposed that the circulation of the toxines of bacteria in the body stimulates the latter to produce another albuminoid substance in the blood-serum which is an antidote to the toxine, and therefore called an antitoxine. The production of this substance must in some cases go on indefinitely, for the animal remains permanently immune against the germ in question; but if the serum of such an animal be introduced into a second one, as just mentioned, the immunity of the latter is only temporary, for the substance appears to be eliminated after a certain interval. Immunity against tetanus produced in this way (by serum) can be transmitted by an immune mother simply by descent, although not to the full strength in which she possesses it; and it can also be transmitted to some extent by the milk of an immune animal. The male parent appears to have little part in this hereditary transmission. Immunity has also been explained by the theory of phagocytosis (Metchnikoff). According to this theory, the power of the leucocytes to destroy bacteria is more active in immune individuals than in others, and that function can be cultivated by a sort of evolutionary process. Whatever the explanation, the demonstrated facts of immunity and of the possibility of producing it by injecting the serum of immune animals have formed the basis of the newly introduced serum-therapy, for it has been found that this serum will not only confer immunity against infection, but will enable the animal to throw off an infection which has already taken place. Diphtheria, hydrophobia, tetanus, anthrax, glanders, and even pneumonia, are instances in which at least partial success has been obtained by this method.

Methods of Sterilization.—Most important, practically, is the question how to exclude or destroy micro-organisms, a question which is very difficult to answer definitely on account of the variations in the vitality of the germs and the possibility of numerous errors in the experiments. Thus, it was long thought that a solution of 1 to 1000 of bichloride of mercury would kill germs, and even spores, with certainty and rapidity, three minutes being the longest time of exposure supposed necessary; but these conclusions have proved erroneous. The usual method of testing such solutions was to put in them a thread impregnated with the germ to be tested, and then inoculate suitable media with the thread, concluding that if the culture medium remained sterile it proved that the germs had been killed. But it has been found that the negative results thus obtained were worthless, for enough of the chemical remained in the thread and the germs to prevent the latter from developing and to keep the culture sterile, although the bacteria were still alive. Washing with water and alcohol proving insufficient to remove the antiseptics, it was found necessary to neutralize them by chemical action, such, for instance, as the use of sulphide of ammonium to pre-

cipitate the bichloride of mercury, and then it was discovered that experiments which had given negative results under the old methods produced abundant cultures (Geppert). By this method it was found that anthrax spores survived ten and even twenty-four hours' immersion in a 1 to 1000 bichloride solution, and that even the *staphylococcus pyogenes aureus* would survive after being kept for twenty minutes in the same solution. Exactly how the chemical antiseptics act in thus suspending growth in living organisms and yet leaving them capable of restoration is not understood, the most probable explanation being that the antiseptic enters into combination with the capsule of the cell, and can be freed from it by breaking up this chemical combination. It has always been evident that very minute quantities of germicidal substances, and some substances which are not germicidal, would prevent the growth of bacteria, so that it is not surprising that chemical disinfectants should act in this prolonged, inhibitory way. It must be remembered that in operative surgical work no such secondary reagents are used, and that germs which will not develop are for practical purposes as good as dead; therefore such results do not entirely invalidate the present methods of sterilization for operations, but they should stimulate us to the discovery of better methods of sterilization, and especially to the thorough application of the methods upon which we are now dependent in order to obtain the best possible results from them. We must, moreover, be particularly careful not to employ corrosive sublimate in wounds, or in the disinfection of substances (fæces) in which sulphur compounds are likely to occur, lest they decompose the chemical and set free the bacteria.

Chemical Antiseptics.—Micro-organisms can be destroyed by deprivation of food or water, by chemicals (including toxines, etc.), and by heat. For practical disinfection, however, only chemicals and heat need concern us. We take from Koch's experiments the following list of the principal chemical antiseptics used, and their power on germs: Complete prevention of growth of anthrax spores was produced by bichloride of mercury, 1 to 300,000 solution; mustard oil, 1 to 33,000; arsenate of potash, 1 to 10,000; salicylic acid, 1 to 1500; carbolic acid, 1 to 850; boric acid, 1 to 800; alcohol, 1 to 12.5. It is yet an open question whether iodoform, as employed in wounds, has any antiseptic effect; it certainly has none in laboratory cultures. To destroy completely the vitality of anthrax spores requires the prolonged action of any chemical, and among the ordinary germicides only bichloride of mercury, pure iodine, and cresol (with the addition of sulphuric acid) can accomplish this within twenty-four hours. Carbolic acid in 1 to 20 solution has failed to kill these spores in thirty-five days; hydrochloric acid requires ten days, and ether thirty days, to destroy them. The power of all these substances is greatly increased by heat, the bichloride of mercury, for instance, killing staphylococci in five minutes at the temperature of the body, whereas it requires over five times as long at the ordinary room temperature. Grease, oil, mucus, and even blood, will cover germs with a coating which prevents chemical germicides from reaching them. Another source of error in the direct application of these experiments to practical surgery is the fact that many of these chemicals are decomposed or rendered inert by combinations with the albuminoids of

blood and pus, mercuric bichloride being transformed into an indifferent substance, and even carbolic acid being altered. The proportional amounts of the germicidal solution and of the matter to be sterilized are to be considered, the action of the former being much more intense when it is abundant. The age of the solutions is also important, and fresh solutions, even of so permanent a salt as the bichloride, have a greater power. We have limited ourselves to a discussion of the means of destroying pathogenic germs, but those of decomposition are often more obstinate and tenacious of life, some of the saprophytes being able to multiply even in a 1 to 44,000 solution of bichloride of mercury.

Sterilization by Heat.—Heat is the surest and quickest method of destroying germs, even the spores being killed. Anthrax spores are killed in two minutes in boiling water, and the various bacilli and cocci in from two to five seconds. When a substance is to be sterilized by heat which will not bear so high a temperature, the method of *fractional sterilization* is employed, the fluid to be sterilized being raised to 140°, 160°, or 175° F. (60°, 70°, or 80° C.) for from fifteen to thirty minutes every day for from three to seven days; the theory being that the adult germs are killed by the first heating, and that any spores which develop subsequently are destroyed in their adult state at the next heating. The fluid meanwhile must be kept at an even temperature, which will encourage the development of any spores it may contain. Even anthrax spores can be killed by heating to 167° or 185° F. (75° or 85° C.) in a one and four-tenths per cent. solution of sodium carbonate for from eight to twenty minutes. Dry heat is not so efficient as moist, for a temperature of 284° F. (140° C.) dry heat continued for three hours is needed to kill anthrax spores.

Staining Methods.—In order to detect micro-organisms in the tissues or elsewhere the use of staining is almost indispensable, and the bacteria stain readily in the various basic aniline dyes, such as gentian-violet or methyl-blue and fuchsin. The last named is much used for coloring *tubercle bacilli* in a solution known as *Ziehl's*, which is made of one gramme of crystals of fuchsin and one hundred cubic centimetres of five per cent. solution of carbolic acid, to which ten cubic centimetres of absolute alcohol are slowly added. The cover-glass *smear* is prepared in the usual way by putting a minute quantity of the material to be examined on one cover-glass, wiping it off with another, and drying it rapidly by passing it through a flame. The cover-glass is floated face down on the solution, which is carefully brought to the boiling-point and kept there for a few minutes. The smear is then decolorized with sulphuric acid, washed in alcohol (sixty to eighty per cent.) two or three times, and rinsed thoroughly in water. Methyl-blue will give a very good counterstain, contrasting with the red bacilli. It is said that the same stain can be used cold, allowing it to act for two minutes, washing in water, then decolorizing as before.

Gram's method is commonly used, and especially because the gonococci are first stained and then decolorized by it, and thus distinguished from certain other forms. The specimen is stained for one or two minutes in gentian-violet or methyl-blue. It is then put in a solution of iodine one part, iodide of potassium two parts, and distilled water three hundred parts,

for one minute. It is decolorized with alcohol, dried, and a counterstain applied if desired.

Varieties of Bacteria.—We proceed to a brief enumeration of the bacteria which are surgically important, beginning with the varieties which are able to produce pus, the chief of these being the cocci.

Staphylococcus pyogenes aureus (Ogston, Rosenbach) (Plate I., Fig. 2) is a globular organism, about 0.7 to 0.9 micromillimetre in diameter, growing in clusters, found very widely diffused, but especially upon the skin and in the pharynx, and causing about eighty per cent. of all the instances of suppurative inflammation. It is the almost universal cause of acute osteomyelitis. It grows upon all the ordinary culture media at ordinary temperatures, but best at from 86° to 98° F. (30° to 37° C.). It forms small circular colonies, with sharp, smooth outlines, often white at first, but generally yellow in color, deepening to orange as they grow (Plate I., Fig. 1, *A*). It liquefies the gelatin, and forms small depressions, into which the colony sinks. It also has the power of peptonizing albumin and coagulating milk. This coccus can be inoculated in animals, causing local suppuration and general septicæmia. It grows both with and without free oxygen, and does not form spores, unless they be arthrospores. It can be stained by any of the methods, including Gram's.

Staphylococcus pyogenes albus (Rosenbach, Passet) and **S. p. citreus** (Passet) resemble the foregoing species in every respect, except that one forms white and the other lemon-colored colonies, and that neither of them is so virulent as the orange variety (Plate I., Fig. 1, *B*).

Staphylococcus epidermidis albus (Welch) is probably only a modified and less virulent form of the S. p. albus, and is found in the deep layers of the cutaneous epithelial cells. Its situation renders it very difficult to destroy, and it is liable to cause abscesses around cutaneous sutures.

Several different **streptococci** have been described, and it is still uncertain whether these are independent species or merely varieties of one species, the majority of bacteriologists at present holding the latter view.

Streptococcus pyogenes (Plate I., Fig. 3) is a globular organism occurring in chains, from $\frac{1}{3}$ to 1 micromillimetre in diameter, especially common in the exposed mucous cavities of the body, such as the urethra, vagina, and mouth. It grows in the usual culture media, slowly at ordinary temperatures, most freely at about the body temperature, forming small circular (rarely oval) colonies, which are at first yellow and later turn brown. The gelatin is not liquefied, and the colonies project above the surface, especially at their centres and on the edges. The streptococcus peptonizes albumin. It produces arthrospores, grows best with free oxygen present, and can be stained by all the aniline dyes, including Gram's method. Experiments on animals appear to indicate that the streptococcus is less virulent than the S. p. aureus, but clinically it is found to excite a more dangerous form of suppuration, with much sloughing and a tendency to spread without limitation. It also causes erysipelas, for Fehleisen's streptococcus of erysipelas is probably identical with the ordinary streptococcus pyogenes, in spite of Rosenbach's efforts to distinguish them, although it may be a peculiarly modified form of that germ. The staphylococci are never found

PLATE I.

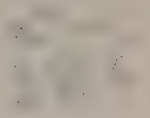
FIG. 1.

A, staphylococcus pyogenes aureus.

B, staphylococcus pyogenes albus.

Tubes of agar-agar, showing growth of micro-organisms. (Pepper.)

FIG. 2.



Staphylococcus pyogenes aureus. (Robb.)

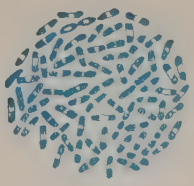
FIG. 3.

Streptococcus pyogenes. (Robb.)

FIG. 4.

Micrococcus gonorrhœæ. (F. C. Wood, M.D.)

FIG. 9.

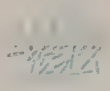


Bacillus diphtheriæ. (Da Costa.)

FIG. 5.

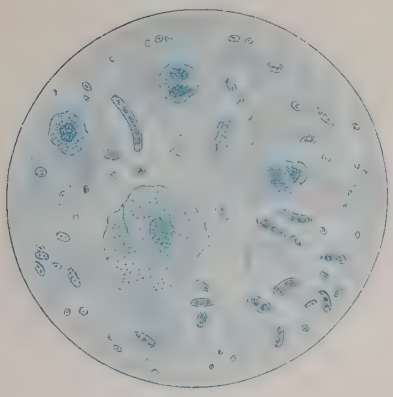
Bacillus pyocyaneus. (Robb.)

FIG. 6.



Bacillus coli communis. (Robb.)

FIG. 7.



The pneumococcus of Fränkel; the cocci are stained dark blue, the capsules are unstained. (After Jaksch.)

FIG. 8.

Bacillus typhi abdominalis, showing flagella. (F. C. Wood, M.D.)

in erysipelas. The streptococcus occasionally causes osteomyelitis, but much more rarely than the staphylococcus.

Micrococcus gonorrhœæ (or gonococcus) (Neisser) (Plate I., Fig. 4) will be described with the disease which it produces.

Bacillus pyocyaneus (Gessard) (Plate I., Fig. 5) is rather a common pyogenic germ, which occurs in the skin and perspiration as a motile body. It grows in cultures at ordinary temperatures, and has the power of liquefying the gelatin, producing a bluish-green color in free oxygen. It is found in pus, to which it gives a blue or green color, sometimes quite vivid.

Bacillus coli communis (Emmerich) (Plate I., Fig. 6) is an important bacterium found in the intestinal contents, in peritoneal exudates, in the urine with cystitis, and occasionally in abscesses. It is a short rod, 2 to 3 micromillimetres long and 0.4 to 0.6 micromillimetre thick, sometimes oval in shape and resembling a micrococcus, motile (having flagella), and occurring in pairs or chains. It stains with the ordinary dyes, but is decolorized by Gram's method. It is easily cultivated, and forms a thin film or a projecting mass on the surface of the medium, of lobulated shape, a yellow color, and granulated appearance. It grows either with or without free oxygen. The cultures are acid, do not liquefy gelatin, but decompose sugar. No spores have been seen. It can be inoculated in animals, causing the same local suppurations or general infections as in man.

Pneumococcus or **micrococcus lanceolatus** (Fränkel) (Plate I., Fig. 7) and **B. typhi abdominalis** (Plate I., Fig. 8) are also capable of causing suppurative inflammation in the cellular tissues and elsewhere, but do not need description here.

B. diphtheriæ (Klebs, Loeffler) (Plate I., Fig. 9) has a certain amount of surgical importance, as it has in rare instances been observed in wounds, but so seldom that it merely requires mention. The other more important bacteria—those of malignant œdema, anthrax, glanders, tuberculosis, leprosy, tetanus, and also the micrococcus of Rosenbach's peculiar erysipelatoid eruption—will be described with the diseases which they produce.

CHAPTER II.

INFLAMMATION.

Definition.—Inflammation may be defined as the reaction of the tissues against injurious influences. This definition is satisfactory from the clinical stand-point, but not entirely so from a pathological point of view, for it is difficult, if not impossible, to draw a sharp line between the changes which take place in the tissues as a result of their efforts to repair damage done by injuries and the alterations which occur as a result of true inflammation, although it is important not to confuse the two. An aseptic wound heals without any of the clinical signs of inflammation or any "reaction," and the definition is therefore satisfactory clinically. It is only by a study of the minute tissue-changes about such a wound that the resemblance between the processes of wound-repair and those of slight inflammation becomes evident.

Etiology.—The cause of inflammation is any injury to the tissues by mechanical, thermic, or chemical means, by the effect of electricity, or by the growth of bacteria. The action of bacteria and electricity can probably be explained by referring it to mechanical effect, heat, or chemical action. The invasion of the tissues by bacteria is the universal cause of such inflammations as come under the surgeon's notice, with the exception of those due to rheumatism and gout, so that one is almost tempted to say that there can be no inflammation without bacteria. Bacteria may act upon the tissues mechanically by their presence as foreign bodies, and perhaps also by the obscure influence known as vital force, but it is daily becoming more evident that their main, and perhaps their only, action is the chemical effect of their toxines and ferments, which have been shown capable of producing pus when injected free from living bacteria into the tissues. The peculiar inflammations found in the altered trophic conditions associated with certain nervous diseases, such as sclerosis or other changes in the spinal cord, are due merely to the ordinary causes, although acting with greater force upon the devitalized tissues.

The various causes of such forms of inflammation as the surgeon is apt to meet with may be thus classified:

A. Mechanical. 1. Contusions, wounds, fractures, ruptures.
2. Foreign bodies, necrotic tissue (sequestra), calculi.
3. Friction, long-continued pressure.

B. Heat, cold, electricity.

C. Chemical. 1. External—irritants, caustics.
2. Internal—gouty and rheumatic poisons, urine, bile, and digestive secretions.

D. Bacteriological.

The first three classes are of so little importance except as *predisposing* causes that we are unable to give any name to the reactions excited by them, with the single exception of gout and rheumatism, whereas in the list of inflammatory affections produced by bacterial infection we find nearly every serious inflammatory condition known to surgery. The conditions known as septicæmia and pyæmia are not included, because we look upon them as sequelæ to bacterial infection and not as distinct diseases; the first being found with any germ, the second only with the pyogenic.

Inflammatory Conditions caused by Bacteria.—

1. Inflammations caused by pyogenic germs (including B. coli, B. typhi abdominalis, gonococcus, pneumococcus, etc.):
   Dermatitis, Furunculosis, Cellulitis, Carbuncle, Erysipelas (probably), Peritonitis, Empyema, Meningitis, Synovitis, Phlebitis, Cystitis, Osteomyelitis, etc.
2. By special germs:

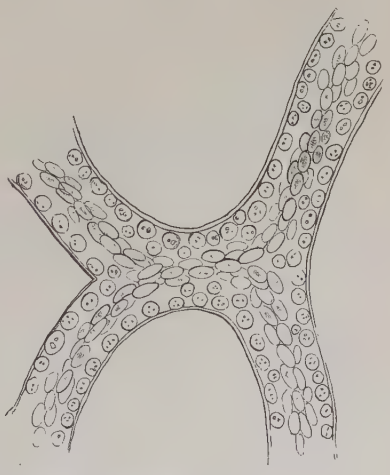
Malignant œdema (Bacillus œdemat. malig.)	Tuberculosis (lupus) (B. tuberculosis).
Anthrax (B. anthracis).	Leprosy (B. leprosæ?).
Glanders (B. mallei).	Syphilis (B. syphilidis?).
Actinomycosis (Actinomyces).	Tetanus (B. tetani).
	Rabies (germ not isolated).

2*a*. Special germs attacking mucous membranes (without previous lesion):

Gonorrhœa (Gonococcus).	Diphtheria (B. diphtheriæ).

Pathological Changes.—The Circulation.—When one of the causes mentioned above acts upon the tissues, the first alteration seen is an increasing supply of blood to the part, the arterial circulation being increased both by greater rapidity of the current through the vessels and by dilatation of all the small branches and capillaries. It has been shown by experiment that if the main artery which supplies each ear of a rabbit be divided and one of the ears have its tip immersed in water sufficiently hot to excite inflammation, the flow of blood from the cut end of the artery upon that side will be greater than that from the other, and since the vessel is thus affected at a distance from the inflamed part, the latter must always have an actual increase in its supply of blood. When the inflammation grows more intense, the circulation of the capillaries becomes slower and the corpuscles collect until they clog the vessels. The normal current of the blood in small vessels as seen under the microscope shows a thick central stream of corpuscles with a transparent border of lymph between it and the vessel-wall, containing only a few white corpuscles. (Fig. 10.) As the stream

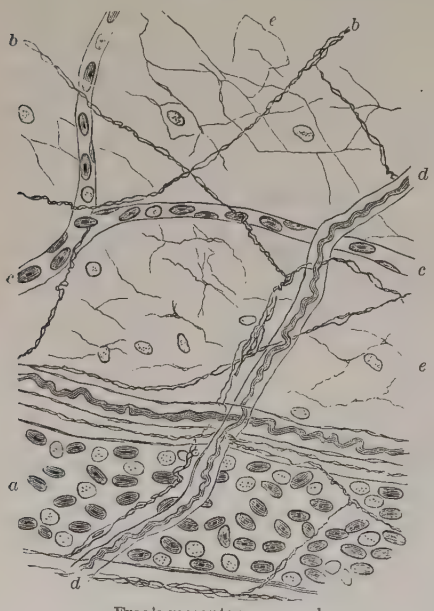
Fig. 10.



Normal circulation in a frog: red disks in centre of stream, leucocytes on the borders. (Agnew.)

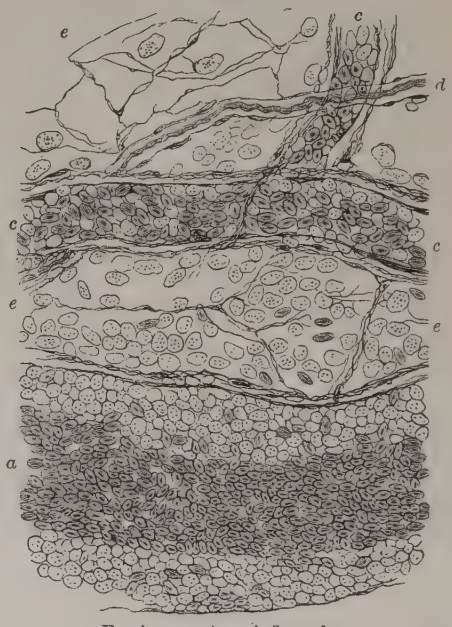
diminishes in rapidity the number of white cells in this clear space increases, the third corpuscles of the blood (blood plaques) appear also, and finally, when the current is reduced to stagnation, the clear space disappears, being entirely filled with cells, chiefly with leucocytes, although even the red corpuscles then find their way into it. (Fig. 11.) This tendency of the white cells to separate from the others, even when the current is still rapid, is partly due to their viscosity and power of amœboid movement, but is in the main a purely mechanical effect of the slower current. It has been proved (Schlarewsky) that, when particles of different density are suspended in a liquid which is circulating through a system of narrow tubes with a very rapid current, there is a clear space next to the wall of the tubes, where the friction necessarily reduces the speed of the fluid, which

FIG. 11.



Frog's mesentery, normal.

FIG. 12.



Frog's mesentery, inflamed.

Figs. 11 and 12.—*a*, small vein; *bb*, *dd*, nerve-fibres; *c*, capillary; *ee*, connective tissue (in Fig. 12 filled with migrating leucocytes). (Agnew.)

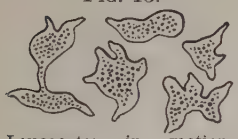
is free from particles, and as the current is slowed down some of the particles of the least density begin to appear in this clear space, their number increasing as the current becomes slower, until even the heavy particles also collect here when it is very slow. It is known that among the cellular elements of the blood the leucocytes have the least specific gravity or density, and the third corpuscles rank next, while the red blood disks are the heaviest, and, as we have seen, these bodies appear in the clear serum near the vessel-wall in that order, according to the law just described. The slow current is associated with an increased intravascular pressure, and the latter produces an exudation of the serum of the blood, which passes out of the vessels and collects in the lymphatic spaces in the cellular tissues and elsewhere, and also exudes from the surface of mucous or synovial membranes,

or forms vesicles or blisters in the skin by detaching the superficial epithelial layers.

Complete stasis, or stoppage, of the circulation is seen only when the inflammation is exceedingly intense and would cause the death of the part if it continued long. This result follows some forms of inflammation, in which the first clinical sign of disturbance is the appearance of necrotic areas, and in which there is little or no accompanying congestion. Usually the current merely becomes slower than normal. This retarded circulation is followed by the phenomena of emigration.

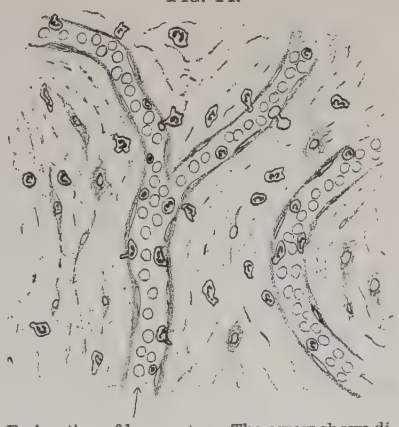
Emigration.—Emigration of the white blood-corpuscles consists in the passage of the cells directly through the vessel-wall. It is most frequently seen in the capillaries, although it may also take place in the small veins. The white corpuscles, or leucocytes, have the property of amœboid movement (Fig. 13), stretching out at will, in any direction, long, narrow processes of their protoplasm (called pseudopodia), which may be attached to any object, and, having secured an anchorage, the rest of the protoplasmic body is drawn towards it. In this way the leucocytes are able to pass through interstices between cells or along narrow channels in the tissues. When the blood-current becomes sufficiently slow to enable them to cling to the walls of the vessels, it will be observed that amœboid movements begin. Sometimes the cells lose their hold and are swept on again, but in other cases a minute bud of protoplasm will appear on the outer side of the wall of the vessel, opposite to the spot where the leucocyte is clinging, and as this grows larger a narrow neck of protoplasm can be traced through the wall directly to the leucocyte, and it will presently be seen that the mass of the leucocyte becomes proportionately smaller as the external bud of protoplasm grows larger. (Fig. 14.) The conditions are gradually reversed, the nuclei of the cell appear outside, and only a small mass of protoplasm remains within the vessel, until finally the entire leucocyte is in the tissue outside of the vessel and is free to wander in any direction. The mechanical part of this process is not yet understood. It is claimed by some that small openings exist in the walls of the vessels between the endothelial cells which line them, to which is given the name of stomata. These openings are ordinarily invisible, but they are said to enlarge under the effect of the dilatation of the vessels and of the alterations in their walls produced by the inflammatory reaction, and that the leucocytes escape through these openings. Others (Metchnikoff) assert that the endothelial cells themselves possess the power of amœboid move-

Fig. 13.



Leucocytes in motion. (Agnew.)

Fig. 14.



Emigration of leucocytes. The arrow shows direction of blood-current. (F. C. Wood, M.D.)

ment, and draw apart so as to allow the leucocytes to pass between them. The vital part of the process is, however, fully demonstrated, and the old theory that the emigration is simply the result of the increased pressure of the blood in the vessels has been given up as an explanation of the emigration in the earlier stages of the inflammation. There can be no doubt that the emigration is due to the amœboid movement of the cells, and the discovery of the phenomenon to which is given the name of chemotaxis affords a sufficient explanation.

Chemotaxis.—Chemotaxis is the influence of attraction or repulsion exerted upon amœboid cells by certain substances. In some cases this attraction appears to be purely mechanical, but it is probably a chemical effect of some kind in most, if not all, instances. Thus, certain low vegetable organisms known as the myxomycetes assume at one stage of their existence the form of a mass of protoplasm with several nuclei, called a plasmodium, which resembles on a huge scale what pathologists know under the name of giant-cells. If this plasmodium is brought near an infusion of decayed leaves it extends its pseudopodia in that direction, dips them into the fluid, and finally passes entirely into it. If, on the other hand, a solution of quinine be brought near it, or be added to this infusion of leaves, the pseudopodia are retracted at once, others are thrown out on the opposite side, and the organism moves away from the solution. This apparent distinction between food and poison is undoubtedly merely a chemico-biological influence upon the organism, and there is no reason to doubt that similar influences would act upon the amœboid cells in the tissues, and even by diffusion through the walls of the blood-vessels. The process of inflammation produces some chemical compound which similarly causes the cells to leave the vessels when there is any inflammatory action in their neighborhood, and to find their way by the shortest route to the seat of inflammation. This is especially well seen in the cornea, in which there are no vessels, but if inflammation be excited in its centre, the emigration of leucocytes from the blood-vessels on the edge of that structure is so abundant that within a very short time the inflammatory focus is full of these cells.

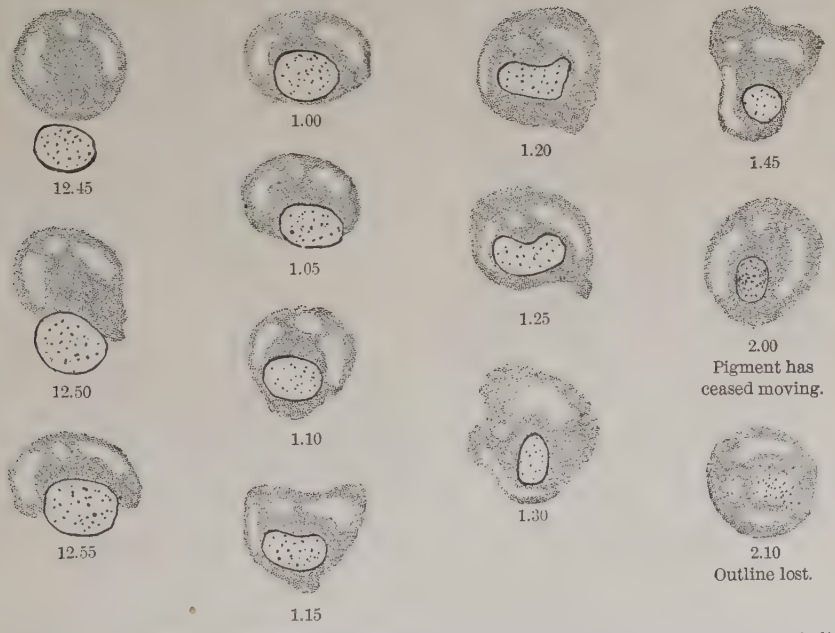
Diapedesis.—When the circulation becomes very slow and the pressure very high, there is a tendency for the third corpuscles, and even the red corpuscles, to leave the vessels. This is a purely passive process, and is observed only when the changes in the vessel-wall are extreme. Both of these varieties of cells die, and are destroyed in the exudate, the former furnishing the fibrin which is so abundant in some forms of inflammation. This escape of the red corpuscles is known as *diapedesis*, and is sometimes so extensive as to amount to capillary hemorrhage.

Wandering Cells.—The leucocytes direct their course through the tissues to the chief point of irritation by reason of chemotaxis, and surround any dead tissue, any point of bacterial growth, or any foreign body which may be the cause. The wandering leucocytes form the pus-cells, and, if they are very numerous, they constitute a purulent or suppurative inflammation. If the inflammation has lasted for some time, evidences of growth and multiplication are seen in the fixed cells of the tissues, and their offspring also add somewhat to the mass of cells which collect at the inflam-

matory focus. Many good observers agree (Grawitz, Shakespeare) that under the stimulus of inflammation many cells appear in the lymph-spaces of the tissues which must have been present previously, although invisible under ordinary circumstances, existing in a "slumbering" state in which they are indistinguishable from the fibres of the connective tissue. This discovery accounts for the immense numbers of cells which suddenly appear as if by magic around any inflammatory agent, for it would seem impossible that emigration and multiplication of fixed cells in the ordinary manner could furnish such quantities of new cells. The wandering cells, however, are almost entirely made up of the leucocytes, of which three forms are known. These three forms are: first, a small round cell with a nucleus so large as to occupy the entire cell; secondly, a similar round cell of much greater diameter, with a single nucleus not so large in proportion; and, thirdly, a round cell as large as that last described, but with several nuclei all united by a narrow band of protoplasm. This third cell is much the most numerous both in the blood and in the exudate, forming in the latter over three-quarters of all the cells present.

Phagocytosis.—The object and effect of the emigration of leucocytes in inflammation are still subjects of dispute. The leucocytes surround any

FIG. 15.



Phagocytosis. Destruction of a plasmodium malariæ by a leucocyte in human blood. The figures indicate the time of observation, the whole process lasting 1 hour and 25 minutes. (F. C. Wood, M.D.)

foreign body, and if the particles are small enough to be taken up the cells incorporate them in themselves—in fact, they may be said to swallow them. This taking up of particles by the wandering cells is called *phagocytosis* (Fig. 15), a process which some observers look upon as more or less accidental, while others, and in particular Metchnikoff, consider that it is

intentional, seeing in it the essential part of inflammation. Metchnikoff thinks that the object of the emigration is to furnish a large number of cells which will take up any foreign substance, such as bacteria or sloughing tissues, or the dead cells of the organism which may have been killed by injury or subsequent inflammation. If the particles are small enough to be taken up by one cell, the latter may carry it away to the blood-vessels or lymphatics, or to some free surface where cell and contents will be thrown off, or it may digest the material it has collected and continue to live.

He claims to have seen living bacteria taken up by such cells, with the result that in some cases the bacteria multiply in the cell and cause its death, while in others the bacteria are digested and destroyed. This he terms a war of cells, and looks upon inflammation as simply a nutritive process by which the tissues furnish the cells to drive out or neutralize the invaders. His theories command respect, but many able investigators still refuse unqualified endorsement of them. Even if we cannot accept the doctrine of phagocytosis, there can be no doubt that the accumulation of wandering cells is useful in limiting the inflammatory action by filling up the lymph-spaces and blocking the lymphatics, and thus mechanically preventing any spread of the cause of the irritation.

Suppuration.—Pus consists of a serum containing little or no fibrin and large numbers of cells resembling the multinuclear leucocytes described above. These cells are for the most part dead or dying, and represent the waste thrown off from the tissues as a result of the inflammatory action. A purulent inflammation or suppurative process is one which results in the production of pus.

Abscess.—An abscess is a cavity which is formed in the tissues and contains pus. A collection of pus in one of the recognized anatomical cavities of the body is known as a *purulent effusion* or *empyema*. When pus is not contained in an abscess-cavity, but is diffused through the cellular interspaces of the subcutaneous or other tissues, the condition is spoken of as a *purulent infiltration*. The wall of an abscess consists of the tissue in which it happens to be situated, thickly infiltrated with cells, the layers nearest the abscess-cavity being formed of the cells alone, while in the outer layers the cells are seen to be less closely placed, and the structure of the original tissue becomes more evident as one passes outward, until normal tissues are reached, there being no distinct outer limit to the abscess-wall. Owing to the fact that the inner surface of the abscess often looks like mucous membrane, formed as it is of the small granulations made up of these cells, it was formerly often spoken of as a pyogenic membrane, a term which has now deservedly passed out of use, for this lining is in no sense a membrane, nor does it produce the pus. An abscess grows by addition to its cellular contents from the softening and loosening of the cellular infiltration about it, under the action of the pus itself, which has peculiar solvent properties, the infiltration spreading on the outer limits, while the most infiltrated tissues on the side towards the cavity are constantly breaking down.

Sloughing.—Inflammation may be accompanied by sloughing or death of the tissue. *Gangrene*, *mortification*, *necrosis*, or *sphacelus* is a death of the tissues from any cause. The part which has died is designated as a

slough, although, strictly speaking, this term should be limited to a dead portion which is already partly separated from the living tissues. The word necrosis is generally limited to the bones, and the slough in this case is also separately designated as a *sequestrum*. Any violent mechanical, chemical, thermic, or electric injury may cause death of the tissue directly involved, and gangrene can also be produced by any cause which entirely suspends the circulation of a part, so that it is frequently found associated with inflammation, either as an accidental complication or as a necessary consequence of that process. During the progress of inflammation the circulation may be shut off from any part of the tissues (1) by mechanical compression of the vessels by the inflammatory exudate, (2) by their obliteration by the growth of bacteria within their walls, or (3) by coagulation of the blood in the vessels by some intense fibrin-producing effect of the inflammatory process. It is, for instance, well known how great is the danger of sloughing when suppurative inflammation attacks the tendons, which are poorly supplied with blood, and often enclosed in narrow, unyielding channels, so that inflammatory swelling may easily shut off their blood-supply. In other cases there is a combination of causes, as may occur in diabetes or at the close of exhausting fevers in which the general system has been greatly reduced and the vital resistance of the tissues impaired, so that an inflammation which would be of little moment in healthy persons may result in the extensive destruction observed in diabetic gangrene of the limbs or in noma of the face and genitals. Finally, there is that class of cases of which hospital gangrene is the type.

Hospital Gangrene, which formerly decimated the inmates of the military hospitals, is now of scarcely more than historical interest, for it disappeared so quickly after the general adoption of antiseptic surgery that no proper bacteriological investigation of it has been made. It is, however, possible that this disease may reappear as the result of overcrowding and neglect. It was undoubtedly due to bacterial infection, and most probably to one of the ordinary pyogenic varieties which attained unusual virulence from the foul wound-conditions then prevalent; but some of the cases resemble the condition known as malignant œdema, which is produced by a special germ and is described on page 50. When hospital gangrene appeared in a wound a thick, pultaceous, ash-colored or yellow slough formed, followed by rapid ulceration spreading at the edges and also at the bottom of the wound. The edges of the wound were everted, the skin was detached and dark-colored, and a zone of inflammation lay just beyond. In a few hours the sloughing would involve a large part of a limb, or destroy the entire side of the body, laying bare the deep vessels and nerves, and often causing rapid death by hemorrhage from the arteries. The ulceration presented a large cup-shaped cavity filled with sloughs emitting a most fetid odor. The patients had fever, and soon became completely septic. The disease could be arrested only by thorough removal or destruction of the infected tissue with scissors and cautery, and sometimes hemorrhage rendered amputation necessary. We describe this disease mainly to illustrate the remarkable effect of antisepsis in banishing immediately a disease of such virulent contagiousness and such universal occurrence.

Gaseous Septic Infections.—An unusual complication of inflammation is the formation of gas in the tissues. This must not be confounded with the escape of gas or air into the cellular spaces from some of the air-containing cavities of the body, for it is a true production of gas originating from bacterial growth. When gas develops in the closed cavity of an abscess it does not necessarily imply that the micro-organisms concerned are unusually virulent or dangerous to life, for it is more particularly the putrefactive microbes which produce these gases. But when it is found in the cellular tissues as a diffuse emphysema, sometimes crackling under the fingers in spots far distant from the original source of infection, or advancing rapidly up a limb, even without any congestion of the overlying skin, it is a sign of the most serious import, and it is seldom that the patient can be saved, even by an amputation done at a point far removed from the nearest sign of emphysema. Some of these cases are instances of malignant œdema, but not all, for there are other forms of septicæmia which are accompanied by the production of gas.

We have observed a general gaseous septicæmia appearing in a patient less than twenty-four hours after an internal urethrotomy done with all the ordinary antiseptic precautions, the patient having a high temperature but no local symptoms, feeling bright and well, and complaining only of a little sore throat, although crepitation was distinct in the subcutaneous tissues of the ankle, and death followed forty-eight hours after the operation. The cause of the infection could not be ascertained. Autopsy revealed no unusual appearance of the urethra, but gas was diffused through all the vessels of the body. Death is said to occur in some of these cases merely from the mechanical effect of the presence of the gas in the blood-vessels, just as when air enters a vein during an operation, but it is more often due to septicæmia.

Symptoms.—From antiquity the local symptoms of inflammation have been enumerated as *rubor*, *dolor*, *calor*, *et tumor*, and to these the moderns have added only one, largely a consequence of the others, *functio læsa*—impaired function. The *redness* is due to the congestion. The *pain* is due to the pressure exerted upon the sensory nerves by the surrounding swelling, as is well shown by the intensification of the distress as every beat of the heart forces more blood into the space already overfilled. In some cases, however, it may be caused by the direct action of the inflammatory agent on the nerves. The *heat* is caused by the increased supply of warm arterial blood, for it has been abundantly proved that the temperature never rises above the heat of the blood, although naturally, in a patient with fever, it will be above the normal temperature of that fluid. The *swelling* is due to the dilated vessels, to the effusion of lymph and cells, and to the presence of pus. The *impaired function* is chiefly caused by the pain, which is often increased by any attempt to use the part, and by the swelling, which prevents its free movement, though the loss of function may also be dependent upon the direct action of the inflammatory cause upon the nerves.

The constitutional symptoms of inflammation are an elevation of temperature, with or without a chill, and the general disturbance due to this

condition, added to the disturbances of certain organs, such as the nervous centres, which are poisoned by the toxic substances produced in the inflamed parts, and the liver, kidney, and intestine, which endeavor to eliminate the poison from the system. The inflammatory products may poison the system in two ways: by the diffusion of their chemical substances, toxines and ptomaines, or by the passage of bacteria themselves into the circulation.

Terminations.—Inflammation may result in resolution, suppuration, necrosis or sloughing, or in the establishment of a chronic state.

Resolution is the termination of an inflammation by the gradual retrogression of all the changes which have occurred. The pain subsides, the circulation becomes more normal, and finally the exudation is absorbed or makes its way to the free surfaces of the body, disappearing in the latter case as serous or purulent fluid. The fluid exudation re-enters the circulation by the lymph-vessels or blood-vessels, and the new wandering cells either die and become disintegrated or, possibly, enter the lymph-channels and the circulation intact. It is denied by the best observers that the wandering cells ever become changed into the fixed connective-tissue cells of the part. If there has been any loss of substance caused by the inflammation, it is restored by processes exactly similar to those of the repair of wounds.

Suppuration.—When suppuration occurs, the cellular exudate or pus may make its way to a free surface, such as a mucous membrane, or may form an abscess or may cause sloughing of the skin over the seat of inflammation, and so escape from the cellular spaces in which it is infiltrated. Pus may be thrown off by a mucous membrane without any actual breach of continuity, the individual pus-cells being discharged singly, like the natural secretion or excretion of the part. Diffuse infiltration of the tissues is the most dangerous form of suppuration. In this variety of inflammation the exudate is brought into contact with the greatest possible extent of absorbent vessels, for as the surface of a sponge is greater than that of a bag which would just contain it, so the surface of these intercellular spaces is much greater than that of an abscess-cavity filled by the same amount of pus. In this form also the bands of cellular tissue lying between and forming the boundaries of these spaces have their nutrition and circulation impaired, and frequently slough, but, as they lie under unaltered skin and still remain partly in connection with the surrounding tissues by their fibres, their elimination is very difficult. The entire skin of the part is frequently detached from the fascia by the sloughing of the subcutaneous tissues before it gives way, and even when it finally yields to the necrotic process the openings formed will be altogether too small in proportion to the extent of the disease beneath, so that healing is still further delayed.

Sloughing.—The separation of a slough or a sequestrum is accomplished chiefly by the new cells, although it is uncertain whether these new cells consist of the wandering cells from the vessels, or whether the cells of connective-tissue origin are also included. Some claim that only the latter are concerned in this as well as other efforts of repair. But sloughs often separate at the height of the inflammatory process before any repair can have begun, so that there is reason to suppose that in some cases at least the sepa-

ration takes place before the connective-tissue cells proliferate, and hence must be due to the action of the lymphocytes. However this may be, a section through the point of separation shows on the one side dead slough, on the other living tissue infiltrated with cells and other products of inflammation, and at the point of juncture (or of separation) the connecting fibres are surrounded by compact masses of lymphocytes, some dead, some living, many containing detritus (granules, fatty globules) which they have taken up from the slough, while the fibres are apparently undergoing rapid dissolution, owing to the solvent properties of the fluids and probably also to the phagocytosis of the cells. When inflammation has subsided, granulation-tissue forms on the living tissue directed towards the slough, and the fibres are destroyed in some way by its vital action. This process is most readily studied in necrosis of bone, and will be further dealt with under that head.

Chronic Inflammation.—The third termination of inflammation is the interruption at some stage of its resolution or suppuration and the continuance of the remainder of the symptoms and pathological changes in this lessened intensity for a more or less protracted time—in other words, the development of chronic inflammation. By chronic inflammation we understand a long continuance of some or all of the changes seen in acute inflammation, but in less intensity, and with a tendency to the production of new tissue by proliferation of the fixed cells of the part affected. This thickening of the tissues is due to the unusual amount of nutrition afforded the cells of the region. As a sequel of acute inflammation, the chronic form is due to a diminished intensity of the original irritation, to the fact that the cells have become accustomed to it, or to changes in the cells produced by the long battle against the irritation, the cells being so perverted that they cannot at once return to their natural state. But chronic inflammation is sometimes observed to arise independently, without a preliminary acute stage, as the result of certain irritants similar to those which excite the acute form, but not so intense, or acting upon tissues which are better able to resist, and responding only by the lower grade of reaction.

The **pathological changes** in chronic inflammation vary with the original cause, and with the tissues affected, more than do those of the acute form. There is an increased vascularity, chiefly noted in the venous capillaries, and unusual richness of cells in the tissues. All the tissues are thickened—the connective-tissue stroma, the walls of the blood- and lymph-vessels, the endothelium, the epithelium, the periosteum, etc. There is an extension of ossification into parts normally not ossified, and a softening and breaking down of normal bone under the influence of the proliferation of cells. In the latter changes the effect appears paradoxical, but in both cases it is due to the abnormal cell-life, for the quiescent bone-cells tend to return to the embryonal active state and to absorb the bone-salts about them, while the quiescent connective-tissue and periosteal cells are roused to unusual activity and produce new bone at the edges of the inflammatory area, where the irritation is less intense and does not prevent deposition of bone. These changes in the tissues are evidently largely conservative, for the abundant cell-production and thickening of the tissues not

only tend to neutralize the irritant, but encapsulate it in a single spot, and tend to close all avenues of entrance to the rest of the system by blocking the lymphatic channels with cells (endothelial proliferation, lymphocytes) and thickening the walls of the absorbent vessels. Among the characteristic changes in the cells in chronic inflammation is the appearance of the *giant-cells*. The origin and function of these bodies, consisting of a large, irregular mass of protoplasm with several distinct nuclei, is as yet uncertain. Certain it is, however, that they are found in the neighborhood of foreign material which the tissues are trying to eliminate or encapsule. Some hold that they consist of numerous small cells which have lost their vitality and become fused together, deducing their origin from the wandering lymphocytes which have been attracted by chemotaxis to the foreign body and are dying. Metchnikoff claims to have seen such giant-cells about the foreign bodies occasionally observed in the lower infusorial animals, which are formed only of an external and an internal layer of cells (ectoderm and entoderm), with an intermediate mass of protoplasm containing amœboid cells corresponding to our lymphocytes, but without blood-vessels of any kind. He supposes that they have formed from these amœboid cells, and advances the theory that, as the foreign body was too large for one of them to take it up into itself, the cells became fused in order to furnish enough protoplasm to surround the foreign body, but the nuclei remained distinct. He denies that the giant-cell represents lowered vitality, and assumes that it is an instance of active fusion of the cells for the better performance of their function of phagocytosis. In certain sarcomatous tumors giant-cells are common, and appear to possess the power of absorbing or causing the absorption of bone with which they are brought in contact, and this may be considered a clue to their functions.

The local and general symptoms of chronic inflammation depend so entirely upon its situation that they can hardly be described here. We merely mention the fact that in long-continued suppuration of the bones or other parts an amyloid or waxy degeneration is apt to take place in the liver, kidney, and spleen, probably due to the circulation of bacterial toxines in the blood. While generally fatal, instances of recovery from this condition have been observed in children. It is recognized by enlargement of the affected organs, and by albuminuria when the kidney is involved.

Treatment.—The general indications to be observed in the treatment of inflammation are, to combat the active and passive congestion of the parts, to relieve tension, to give free issue to the products of inflammation, to promote the early separation of sloughs, and to assist elimination of toxines by the skin, bowels, and kidneys. No specific has yet been discovered to act directly against the bacteria which cause cellulitis and allied inflammatory processes, unless the claims of the new serum therapy be established. The most that the surgeon can do at present is to assist the tissues in their attempt to neutralize and limit the action of the invading germs.

Elevation.—The active congestion can be relieved in the first place by placing the inflamed part on a higher level than the rest of the body and by securing as complete immobilization as possible. The patient should be confined to bed, or, if this is not possible and the arm is affected, it should be

placed in a sling, or, if the foot is involved, it should be allowed to rest on a high support. In some peculiar cases local bloodletting by scarification is useful, but general bleeding should never be employed, for the patient will need all his vitality to resist septic infection.

Heat and Cold.—Very cold or very hot applications to the seat of inflammation will relieve the pain, lessen the congestion, soften the parts so as to reduce the tension, and thus assist the tissues in their struggle against the invading germs. It is probably of little moment whether heat or cold be employed, so long as the applications be made continuously, for an alternation of heat and cold is a stimulant to the circulation, whereas the continuous application of either is a sedative. Extremes of heat and cold have the power of contracting the calibre of the blood-vessels, but the action of heat is apparently more lasting and less apt to be followed by a reaction from subsequent paresis of the vascular walls, and hot applications are, as a rule, more agreeable to the patient than cold. Every surgeon has his own preferences, and personally we have observed the best effects from hot poultices in such conditions as cellulitis, whereas in peritonitis and meningitis the use of the ice-bag and cold coil has given us the best results, possibly because in these diseases the general elevation of temperature is a dangerous condition in itself, and this fever is directly reduced by the application intended to affect the local lesion. A poultice should not be applied to an open wound or ulcer, because it becomes quickly foul with the discharge, and it should always be sterilized by boiling before being used.

Wet Antiseptic Dressings.—With the demonstration of the bacterial origin of inflammatory affections the use of various antiseptic substances as external applications to the inflamed parts became universal, and, in spite of the early proof of the fact that none of these substances could be made to penetrate the skin in sufficient quantity to affect the growth of micro-organisms beneath it without poisoning the individual by constitutional absorption, the practice is still prevalent. It is well proved that in order to destroy or even seriously hinder the growth of germs a considerable quantity of any of the antiseptic substances as yet known must be brought in contact with them, and it is self-evident that any substance which passes inward through the skin and other vascular tissues must be taken up by the blood in the vessels and carried away, so that it would reach any other part of the body as quickly as any inflamed deep parts. We are as yet without an antiseptic material which can affect the growth of germs and yet will not injure the patient, so that such absorption as this would be of very serious moment. These facts prove the absurdity of applying dressings wet with carbolic acid or corrosive sublimate solutions to the unbroken skin over inflamed areas. Any benefit which has been observed to follow their use has undoubtedly been due to the effect of the moisture and warmth or cold (according to the temperature of the dressings) thus obtained, while local sloughing and general constitutional poisoning are a common result of such applications. In some cases an attempt has been made to cause absorption of the antiseptic by scarifying the surface, but with doubtful effect. A light gauze dressing applied cold and kept constantly wet with any evaporating solution will greatly relieve the congestion, and so assist the inflamed tissues

in their contest with the irritating material. A thick wet dressing made with a hot solution and well protected against evaporation so that it will retain its heat will produce the same effect, acting like a poultice, although less powerfully. When there are discharging wounds or raw surfaces, one of the methods just described should be employed, for poultices are then inadmissible, and the weak antiseptic solutions will prevent additional infection of the discharge. Astringent solutions applied either cold or hot have an excellent effect upon inflammatory processes, and the most generally useful of these is the one per cent. solution of acetate of aluminum. The best formula for this is Von Burow's: ℞ Aluminis, ʒvj (24 grammes); plumbi acetatis, ʒixss (38 grammes); aquæ, Oij (1000 grammes). M. S.—Filter after standing twenty-four hours.

This solution is strongly astringent, somewhat antiseptic (25 parts to 1000 preventing development of bacteria), not poisonous, and so little irritating that it can even be used about the face without danger of conjunctivitis.

Injections of Antiseptics.—To overcome the difficulties of bringing the antiseptic substances in contact with the micro-organisms through the unbroken skin, it has been suggested that they should be injected by the hypodermic syringe directly into the inflamed area. In some cases an immediate limitation of the inflammation has thus been secured, but the method is painful and there is danger of constitutional poisoning. The best results have been obtained in very superficial inflammations, such as erysipelas, and in specific chronic inflammations, such as tuberculosis. In the former injections of corrosive sublimate in 1 to 5000 solution are made a short distance from the advancing edge of the inflammation. In the latter iodoform in some form is injected directly into the tubercular focus. We may also mention the treatment of lymphadenitis due to venereal diseases when the gland is thoroughly broken down by suppuration, by injection of iodoform into the cavity after discharge of the pus. We refer to the special sections for details.

Mechanical Astringents.—Attempts to modify the circulation and to prevent the spread of inflammation have been made by compression of the tissues just beyond the inflamed area by the painting of bands of contractile collodion on the skin or simply tight strapping with plaster. This will be mentioned under erysipelas, as it is in that disease that the best effects are obtained.

Permanent Irrigation and Baths.—When there are abscesses, joints, or other cavities, or sinuses with a tendency to a retention of pus, permanent irrigation is one of the best methods of treatment. Drainage-tubes are inserted into the bottom of the abscess or cavity to be irrigated and into all the sinuses, and one or more of these tubes are connected by rubber tubing with a vessel above the bed containing a very weak antiseptic solution (acetate of aluminum 1 to 500, or bichloride of mercury 1 to 10,000), which is allowed to run slowly into the cavities and sinuses, making its escape at the more dependent openings into a rubber sheet so arranged as to conduct it from the bed. It is necessary to suspend the part to be irrigated upon strips of bandage tied across a frame in such a way as to keep the part above the level of the sheet, as it becomes macerated by lying in the water. The

frame may be of wood or heavy wire, resting on legs or hanging from a support above the bed. In some cases permanent baths have been successfully employed, the part being suspended by bandages in a similar way in a small bath-tub beneath the level of the fluid. The latter method answers for large superficial lesions, but the irrigation is better for cavities.

Incisions.—While the means already described enable us to combat the congestion and therefore relieve tension to some extent, the relief is only partial. If resolution of the inflammation does not speedily occur, tension must be relieved by dividing dense tissues which surround the inflammatory focus, or by giving exit to the inflammatory exudate. It is sometimes necessary to incise the inflammatory focus very early, before pus appears, in order to prevent the sloughing which will follow if the intense pressure which is strangulating the parts and entirely shutting off their blood-supply is not relieved at once. Early incision may also be necessary to obtain relief of tension which is causing the absorption of dangerous amounts of toxines from the inflammatory focus, or the inflammation may be so situated that immediate interference is necessary in order to exclude all possibility of subsequent invasion of important organs, as in facial carbuncle, which may infect the veins and then extend back through the orbital vein to the cerebral sinuses. As a rule, however, incisions are not required until pus has formed, and the surgeon must be guided by the symptoms.

Indications for Incision.—Pain is an excellent sign of tension, and if it is found to continue or even to increase in spite of the thorough and intelligent use of ice-bags or poultices for twenty-four hours, especially if the pain is sufficient to prevent sleep, an incision is urgently needed. In some cases, however, dangerous inflammation may exist without much pain. If a *brawny infiltration* of the subcutaneous tissue exists, its edge being prominent under the skin almost as if the cellular tissue were injected with wax, and especially if it is extending, immediate incision is necessary, for such inflammations seldom resolve or form well localized abscesses, but cause extensive sloughing, and any delay will result in greater destruction of tissue.

Fever and Rigors.—The elevation of temperature will generally be proportionate to the amount of tension in the inflamed part and to the kind of toxine which is absorbed, and both demand relief by the knife as soon as they become at all marked. With the febrile movement there will be a chill in some cases, and when chills appear after a period of fever they can be taken as a proof that pus exists. In pyæmia a chill sometimes marks the beginning of every fresh abscess. But it should be especially noted that these chills are merely the reaction of the body to certain bacterial poisons, and are by no means a pathognomonic sign of the presence of pus.

Physical Signs.—The physical signs of the presence of pus in the tissues are the evidences of elastic distention and fluctuation. *Fluctuation* is the sensation communicated by the wave of fluid playing in a closed cavity or sac, and it is produced by holding one hand or finger lightly but steadily in contact with the surface of the suspected swelling, while with another a quick impact is made upon the same at a point as far distant as possible. A sensation similar to this can be obtained from any of the large muscles of the body if the test is made at right angles with the long axis of the muscular

fibre; hence an examination for fluctuation in a swelling situated under a muscular layer should always be made parallel with the length of the fibres of the latter. The symptom sometimes cannot be detected in abscesses, because the walls are so dense that the fluid wave cannot be felt through them, or because the cavity is not completely distended with the fluid. In the latter case pressure upon the sides of the cavity will collect the fluid in the part immediately under the fingers and bring out the sign. An aneurism or a soft, rapidly growing sarcoma has frequently been taken for an abscess, and in any doubtful case the incision should not be made until examination shows the absence of thrill and the exploring syringe has demonstrated the presence of pus.

When pus is detected in an acute inflammation it should be discharged by incision at once. If an incision is postponed, the cavity of the abscess will increase, surrounding tissues will be further destroyed, vessels may be opened as their walls are softened by the solvent action of the pus, and hemorrhage take place, or vessels may be blocked and gangrene may result, not to mention the danger that the abscess may burst through its wall and invade the peritoneal or the pleural cavity, or one of the hollow organs, such as the bladder or the bronchi. This bursting of the abscess may have both infectious and mechanical results, either pneumonia or suffocation being the consequence, for example, when the pus enters the bronchi. There is, moreover, a constant absorption of toxines, which can be arrested only by discharge of the pus, and no one can tell at what moment a fatal septicæmia or pyæmia may be set up.

The Incision.—In a well-limited abscess a single incision is usually sufficient, being placed, if possible, at the most dependent portion, so that the discharge will naturally flow from the cavity by the most direct route. If the cavity is rather large, another incision may be made above to allow irrigation. This method of making two incisions is called *through drainage.* Such simple abscesses will generally heal readily under a plain dressing without irrigation, a small tube or wick of gauze being placed in the incision until the cavity contracts. In some regions it is wise to limit the interference to the least possible extent, so as to avoid the production of disfiguring scars, but a small incision is apt to be followed by prolonged suppuration. Free incision and packing insure the most rapid and complete healing of the cavity, and should be the method of choice in the general treatment of abscess. When septa are found dividing an abscess-cavity, they should be broken down, for they will interfere with proper drainage, and of course all sloughs should be removed unless there is danger of hemorrhage.

In making incisions to relieve tension, when the life of the parts, if not the life of the patient, is in danger, the incisions should be carried beyond the edge of the induration into healthy tissue, and the very centre of the inflammatory focus must be laid bare. In case of extensive cellulitis, it will be necessary to make incisions of great length, or a large number of moderate incisions, and if the focus is in the bones their medullary cavity must be opened up. The size and depth of the wounds are of secondary importance. In some inflammatory processes of limited extent but great

virulence the entire focus may be excised like a tumor, the knife being kept outside of the diseased tissue on all sides, or the infected part may be completely destroyed by the cautery.

After-Treatment.—Some surgeons irrigate every suppurating cavity as soon as opened; others prefer to let nature clean the cavity, fearing that irrigation may wash out clots and result in serious hemorrhage, and pack the cavity with iodoform gauze or sterilized gauze for the first twenty-four hours. At the second dressing the cavity may be irrigated with simple sterilized water or with boric acid solution, or with antiseptic solutions, such as 1 to 5000 bichloride of mercury or 1 to 50 carbolic acid. If the cavity is not laid widely open and packed, a tube or a tent of gauze is to be kept in place until it has fully contracted. The dressing is to be changed as often as it is soaked through with the discharge, or whenever pain and fever indicate any retention of discharge in the cavity. Although it is possible to obtain good results by dressing abscesses with simple sterilized gauze, we prefer some mild antiseptic (1 to 3000 or 5000 bichloride of mercury solution) in the gauze, because of the tendency to decomposition of the pus.

CHAPTER III.

SAPRÆMIA, SEPTICÆMIA, PYÆMIA.

UNDER the general term septicæmia we include certain conditions which are not to be considered as independent diseases, but as advanced states or sequelæ of the local bacterial invasion known as inflammation. *Septicæmia* may be defined as that morbid condition of the system caused by the presence of bacteria or their toxic products in the blood. Practically, we limit the term septicæmia to the effects of those bacteria which cause the acute surgical infectious diseases, although there is no pathological difference between the condition of general infection seen in typhoid fever and that of erysipelas, the constitutional symptoms in both cases being due to entrance into the circulation of germs or the toxic products of germs growing in the local lesions of the skin in the latter case, and of the intestine in the former.

Sapræmia.—We distinguish between the poisoning of the system due to the absorption of the toxic products of the germs of decay and those of disease, calling the first sapræmia, the second septicæmia, because of the important clinical difference between the two. As the ordinary saprophytes cannot exist in living tissues or the blood, the only manner in which they can affect the body is by the introduction of their toxic products into the circulation, producing sapræmia. If these bacteria are implanted in a clot of blood, in any necrotic tissue, or in pus anywhere in the body (all being dead matter in which they can grow), decomposition sets in, usually with the production of gas, and always with the production of ptomaines. If no pyogenic or other special bacteria are implanted with the saprophytes, there is no inflammation, but the surrounding tissues absorb these chemical substances, and the whole body is poisoned by their presence in the blood.

Symptoms.—There will be an elevation of temperature, with chilly sensations,—although a true chill may not occur,—flushed skin, rapid pulse, dry, coated tongue, loaded urine, and constipation, followed by diarrhœa. This intoxication is rare in its pure form, but may develop from a putrid placenta or clots retained in the uterus after labor, or from a large imperfectly drained abscess, the prompt recovery of the patient after removal of the cause of intoxication proving that pyogenic or pathogenic bacteria are absent or so scanty as to be of no moment. An intoxication of this kind is never found until two or three days, or even longer, after the bacterial infection. It begins gradually, for the putrefactive germs must grow to a certain extent before they can produce enough ptomaines to poison the system. A complete removal of the decomposing material, moreover, cuts the process short, just as evacuation of the stomach will cause the symptoms of mineral poisoning to cease as soon as the poison which has already been absorbed

and entered the system is eliminated. These two facts enable us to make the diagnosis of sapræmia. It should be noted that gas production and foul odors are not always found in decomposition.

Treatment.—The treatment consists in removing the decomposing blood, pus, slough, or other decomposing material, as far as possible, disinfecting what cannot be removed and the surrounding parts, assisting elimination of the poison by the bowels, the kidneys, and the skin, and administering nourishing, easily digested food and stimulants.

Septicæmia.—Septicæmia must be divided into at least two varieties, one due to the bacteria themselves, which may be called *progressive septicæmia;* the other due to their products, to which may be given the name of *septic intoxication*, or *toxæmia*. There is no one germ which is responsible for all varieties of septicæmia, for apparently any of the pathogenic varieties is capable of producing the condition.

Septic Intoxication.—In septic intoxication, or toxæmia, the patient shows symptoms due to the absorption by the blood of the ptomaines and toxines produced by some focus of growth of the bacteria in the tissues. Fever is almost always present, with its various effects, but the symptoms are not merely those of the febrile state, for many of them are the direct results of the toxines acting upon the different nerve-centres and other organs. The indifference amounting to somnolence, the delirium or coma, and the great prostration are chiefly the direct effects of the poison. The nausea, vomiting, and diarrhœa, as well as the polyuria, suppression of urine, or albuminuria often seen, are due to the efforts which the system is making to eliminate the poison, and to the irritant effect of those substances. Sweating also occurs, although not so constantly as in pyæmia, and indicates a similar attempt, while an evanescent erythema or urticaria shows the irritation excited in the skin by the poison.

Treatment.—If the original focus can be thoroughly disinfected, the symptoms of septic intoxication will disappear very rapidly. If this cannot be accomplished, and the local growth of bacteria continues, the patient will succumb to the depressing effects of the toxines, and this result may take place, in cases of ordinary severity, in a few days. The general treatment will be the same as that of progressive septicæmia.

Progressive septicæmia is the worst form of sepsis, and one which can be resisted only by preventing its occurrence, for when the bacteria have once entered the blood, few persons are able to withstand the attack, and the issue is almost always fatal. In such cases, in addition to the original focus of disease there is the danger that the germs may multiply indefinitely in the blood and found colonies in other parts of the body. Fortunately, the blood can destroy, or at least limit the growth of, certain bacteria (anthrax) if the amount invading it is not too great. In spite of the enormous quantity of germs circulating in the blood, it must not be supposed that they can be found in any drop which may be examined, for experience has shown that their actual demonstration in the blood is a matter of the greatest difficulty, and is usually impossible even when they are so abundant that minute quantities of the blood will produce infection in animals. The usual channel by which the bacteria enter the circulation,

however, is through some vein which is involved in the inflammation. The bacteria penetrate its walls, and either enter the blood directly or cause a thrombus and enter the clot, small pieces of which are detached and carried off into the circulation. It is supposed by some that bacteria may also indirectly reach the blood by means of the lymphatics. Some forms of bacteria are able to live in the blood, multiplying there in such quantities as to block the small vessels (a condition called infarction) and thus cause gangrene mechanically.

Symptoms.—The symptoms of this disease are the same as those of septic intoxication, with the addition of others due to the mechanical effects of the bacteria in the blood-vessels and to the progressive development of new foci of disease. The general symptoms are more intense, because the toxines are produced in the blood itself, where they can exert their full effect, instead of being absorbed from some place of production outside of the vessels, and as they are also constantly increasing in amount, in proportion to the multiplication of the bacteria, the symptoms become constantly worse. Fresh symptoms may be added from time to time as other parts of the body are attacked, depending upon the organ affected. One of the most constant of these is enlargement of the spleen and the lymphatic glands. The secondary effects of progressive septicæmia may be suppurative or non-suppurative inflammations. The suppurating lesions we shall consider by themselves under the head of *Pyæmia*. The non-suppurating inflammations attack the veins, the endocardium, the kidney, the mucous membrane of the intestine, the meninges, the pleura, and other parts.

Treatment.—This is the field of serum-therapy, of antitoxines, and we look to the future to provide us with some such agents which can be introduced into the body, by hypodermic injection or otherwise, and will be capable of destroying the germs or enabling the tissues and blood to destroy or neutralize them without injury to the patient. Some success has been achieved in this direction in the case of rabies, tetanus, diphtheria, and even pyogenic septicæmia, but the subject is still too undeveloped for profitable discussion of its results. As yet the treatment of this condition is practically limited to disinfecting the original focus and any secondary one, so far as this can be accomplished, and to supporting the strength of the patient in the hope that the amount of infection of the blood does not exceed his powers of resistance. Easily digested, nourishing food, such as milk and extracts of beef, must be given in suitable quantities and as often as the digestion is able to dispose of them, aided by peptonizing agents and bitters. Stimulants must be administered in large amounts,—whiskey, brandy, wines, and liqueurs. The skin, bowels, and kidneys must be kept active. If there is diarrhœa, it is not to be completely suppressed, for it aids in the elimination of the toxines, but it should be held in check with opium sufficiently to allow of proper absorption of the food. Where the vomiting is marked and uncontrollable, rectal feeding will be necessary. Drugs are of little value, but sparing use may be made of morphine and quinine as heart and nerve tonics, and, if the stomach is not disturbed, iron may be employed in the form of the tincture of the chloride. Some of the septic toxines act similarly to strychnine or atropine, and it is possible

that one of these drugs may be useful to counteract effects similar to those produced by the other, and either of them, in small doses, is a good heart-stimulant. There can be no question that the free use of pure oxygen by inhalation is one of the best means for combating the depression of septicæmia.

Pyæmia.—That variety of progressive septicæmia known as pyæmia deserves separate consideration. Pyæmia is a morbid condition due to the presence of pyogenic bacteria in the circulating blood, either free or contained in pus-cells or thrombi, resulting in multiple suppurative inflammations throughout the body. These suppurative inflammations may attack the synovial and serous membranes, or produce abscesses, and are called *metastatic* because they develop at a distance from the original focus. Like all forms of septicæmia, pyæmia can appear only as the sequel of some local inflammatory process. The former idea of its etiology was that the pus-cells actually entered the blood-vessels, as, for instance, when an abscess lay in contact with a vein and the wall of the latter was perforated by ulceration or sloughing, allowing the pus to enter it, an occurrence which has been observed, but which must be very rare. It is only necessary, however, for the pyogenic bacteria to gain access to the circulation by directly penetrating the walls of a vein, or by infecting a clot which has formed within it, in order to produce metastatic suppuration. The blood normally remains fluid in the vessels on account of the peculiar influence of the endothelial lining, and does not coagulate even if it be imprisoned and stationary in a part of a vessel included between two ligatures. But if the endothelial surface be roughened by mechanical means, such as scratching by a needle or by inflammation, fibrin will be deposited and a clot formed, which is known as a **thrombus.** The formation of such a clot, **thrombosis,** is the natural consequence wherever bacteria fasten themselves upon the wall of the vessel, whether they are brought to the spot by the circulating blood or penetrate the vessel from without. These thrombi not only interfere with the circulation, but form an element of serious danger, as they are apt to extend, and may reach and project into another branch of the vessel which is still pervious (Fig. 16), and then the blood-current may detach small fragments (called **emboli**) and carry them into the circulation. **Embolism** is the blocking of any arterial vessel by a clot brought to it by the circulation. If the artery obstructed has no anastomotic branches with a neighboring artery beyond, death of all the tissues dependent upon it must follow, and even if there is sufficient anastomosis to prevent gangrene, the tissue may be so poorly nourished that infection takes place very readily. If the embolus contain pyogenic germs, even when the circulation is not impaired, metastatic abscesses will develop.

Fig. 16.

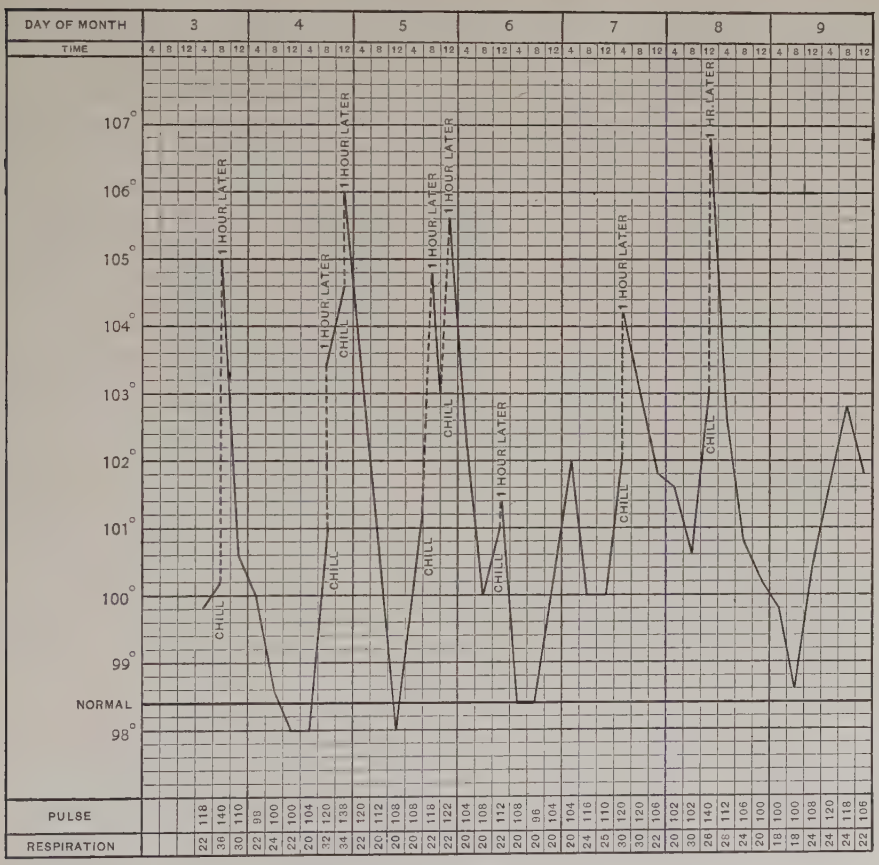
Thrombosis, with clot projecting into the main trunk, so that the current shown by arrow would tend to wash off a fragment. (Agnew.)

A metastatic suppurative inflammation may affect any of the joints or of the serous membranes, producing synovitis, endocarditis, pleuritis, or meningitis, for instance, with their usual results. This secondary inflammation appears to be due to the lodging of bacteria in the

capillaries and to minute emboli. In rare cases only a serous inflammation will be produced, a result which is to be ascribed to a weakened virulence or to the small number of the germs which reach that spot.

Symptoms.—The symptoms of pyæmia are a febrile movement, ushered in by a severe chill, followed or accompanied by a sudden marked rise of temperature to 103° or 105° F. (39.5° or 40.5° C.), or even more, which lasts a few hours and passes off with violent sweating. The paroxysm is repeated, and the intervals may be so regular as closely to resemble malarial fever.

Fig. 17.



Temperature sheet in a case of pyæmia.

But the distinctive feature of pyæmia is the great irregularity with which the febrile attacks occur, the interval varying from a few hours to several days. (Fig. 17.) Although the usual type presents very severe symptoms, there are cases in which there is only a little chilly sensation and a slight rise of temperature, so trifling as not to prevent the patient from attending to his ordinary business. The formation of new suppurative foci is generally marked with a chill and febrile movement, but it is not to be assumed that every such attack signifies the invasion of a new territory, for the mere presence of the poisonous materials circulating in the blood is suffi-

cient to account for it. The febrile movement may be accompanied by nausea, delirium or somnolence, flushed face, and diminished high-colored urine.

The formation of the abscesses, or the beginning of inflammation in a fresh place, is not always accompanied by pain; in fact, pain is rather rare in pyæmia. The surgeon should make a daily routine examination of the entire body, for he will often be astonished by discovering new abscesses, inflammation of additional joints, or a fresh endocarditis or pleuritis, which have developed within twenty-four hours without any symptoms. The subcutaneous abscesses and the synovitis of superficial joints will present much less tenderness, tension, and redness of the surrounding skin than are usual in such inflammations.

As the disease progresses, great prostration ensues, diarrhœa sets in, the delirium or somnolence passes into a low typhoid mental state, and the patient dies from exhaustion. This fatal result usually takes place within two weeks, but it may be postponed for months. As a rule, the chronic cases are more likely ultimately to recover. The milder cases, however, may suddenly sink into a hopeless condition, and even the desperate cases will in rare instances slowly improve, and recovery may take place, with a convalescence protracted through months. Besides the well-marked cases there are others of a doubtful character and very chronic course, in which the original seat of infection may be some unrecognized or neglected inflammatory condition in the urethra or in the nose, for example, the only symptoms being the appearance from time to time of indolent abscesses, such as have been described, with very slight febrile disturbance, which is apt to be ascribed to chronic malarial poisoning. We have seen such a case run a course of two years, with subcutaneous abscesses and synovitis of the knee-joint, the final outcome being unknown to us, in which the primary infection was probably in the urethra, but no gonococci could ever be found in the pus of the secondary lesions. The prognosis in pyæmia is best when the abscesses are limited to the cellular tissues, not so good when a joint has been involved, and very bad if abscesses occur in any of the viscera.

Treatment.—The treatment of pyæmia is the usual supporting one to be employed in septic affections, and all suppurating foci must be opened and thoroughly drained as soon as detected. Every branch of the irregular cavities must be discovered and drained at the most dependent part, and the sinuses must be carefully examined daily in order that no pocketing take place, for they have a peculiar tendency to burrow in every direction.

ULCER, SINUS, FISTULA.

In connection with inflammation, especially with the chronic form, we must consider three allied conditions, ulcer, sinus, and fistula, which are among its results, but are classified apart because of their clinical importance.

Ulcer.—An ulcer may be defined as a loss of continuity upon one of the free surfaces of the body which shows no tendency to heal. Ulceration is the process of molecular gangrene of a superficial part which results in the production of an ulcer, and this term should not be applied to indicate the

mere presence of an ulcer, as is frequently done in speaking of ulceration of the throat or rectum. Ulcers must be distinguished clinically, on the one hand, from fresh or granulating wounds, for as soon as an ulcer begins to heal it ceases, strictly speaking, to be an ulcer, and, on the other hand, from the mode of extension of an abscess, although pathologically we may not be able to distinguish between these conditions and an ulcer.

Etiology.—Ulcers are the result of local causes, such as injury, infection (pyogenic, tubercular, syphilitic, etc.), the breaking down of neoplasms, and interference with the circulation by varicose veins, pressure from within by the growth of benign tumors, or embolism. The great majority are also partly dependent upon constitutional conditions causing a lowered vitality, such as acute or chronic diseases (typhoid fever, syphilis) or mineral poisoning. The constitutional condition is generally the predisposing, and the local lesion the exciting, cause of the ulcer. Sometimes no definite cause is discoverable, and such ulcers must still be termed *simple ulcers*. Chronic ulcers of the skin are three times more common in men than in women, and the aged are not more liable to them than persons in middle life. The most frequent site for these ulcers is on the leg, owing to the greater liability of that part to impaired circulation and to injury. They are often associated with varicose veins, but the large number of individuals with such veins who never have ulcers shows that there is no absolutely necessary causal relationship. It may be that varicose veins do not cause ulcers unless the dilatation has involved the minute venous radicles in the skin. Tuberculous and syphilitic ulcers are described on page 39.

A **simple ulcer** presents a base covered with more or less healthy granulations, nearly level with the surrounding skin, a rather regular circular or oval outline, and a scanty serous or sero-purulent discharge, with few if any inflammatory signs about it. When the ulcer becomes **chronic** or **indolent**, the granulations become paler and smaller, the edges thickened and indurated, and the discharge thinner and more abundant. When still further deteriorated the base of the ulcer is without granulations, but is covered with a thin, white, necrotic layer, which on removal discloses a white or pale pink surface as smooth as mucous membrane. In some cases the surface looks quite raw, as if it were a fresh injury, so that skin, connective tissue, and muscular fibres can be distinguished at the bottom if muscle happens to lie beneath the ulcer. The base lies below the level of the surrounding skin, and is sometimes deeply excavated. The edges are thick, sloping gradually or rising abruptly from the base, and very hard, the induration also extending beneath the base of the ulcer. The discharge is very thin, and may be profuse or scanty, usually the latter. The surrounding skin is not inflamed, and the whole picture is one of lack of vitality. If such an ulcer becomes **inflamed**, dermatitis and cellulitis will appear around it, the base will become reddened, and the discharge purulent; but granulations seldom appear even then, or if they do they soon perish. Sometimes the thickened edges become uneven and warty, and epitheliomatous degeneration sets in, the induration spreading into the surrounding skin, and friable, granulation-like prominences, which bleed readily, appear in the base of the ulcer, with a foul discharge. Varicose

ulcers frequently arise from minute points of phlebitis in the small varicose veins of the skin, resulting in the formation of an abscess and sloughing of the cuticle over it, the ulcer enlarging by molecular necrosis of the edges or by the coalescence of several such periphlebitic abscesses. (Fig. 18.) Such ulcers are apt to have rather irregular undermined edges. Any injury to a limb with varicose veins is apt to result in an ulcer unless extreme care be taken during the healing, and such ulcers resemble simple or chronic ulcers elsewhere except for the deep blue color often seen in the granulations. Hemorrhage from varicose ulcers is not infrequent, and alarming amounts of blood may be lost.

Fig. 18

Varicose ulcer of leg.

Phagedæna is the name given to a rapid form of ulceration most frequently seen in connection with venereal ulcers or hospital gangrene, which is undoubtedly due to some form of bacterial infection, although its precise cause is not known. The ulcer spreads with great rapidity, with or without the production of large sloughs, so that in a few hours the extension is very marked, the skin and the tissues at the base of the ulcer appearing to melt away under its influence. This form of ulceration is, fortunately, of very rare occurrence.

Treatment.—The treatment of ulcers must be directed to subduing any inflammation which may be present, removing all causes of sepsis, improving the circulation, promoting absorption of the induration, stimulating granulations, encouraging cicatrization, and, finally, to covering the defect in the skin by transplantation or grafting, if necessary. Many of these indications can be met by some single method of treatment, but none should be neglected, for the surgeon will need to make every possible effort in order to cure these intractable lesions.

Inflammation is reduced by the same measures as dermatitis or cellulitis elsewhere. The parts are rendered *aseptic* by thorough washing and sterilization with chemicals as usual, and nothing is so essential to success in treatment as the complete maintenance of aseptic conditions. The *circulation* is improved by rest in bed, elevation of the part, and the pressure of bandages when there is venous congestion. Sometimes the elastic pressure of a pure rubber bandage properly applied and worn while the patient is up is all that is necessary to obtain a cure. These rubber bandages are generally known as Martin's. The ulcer should be dressed lightly with some simple solution or powder and a few thicknesses of gauze under the bandage. Elastic stockings are not to be recommended for cases of ulcer of the leg, for they are soon ruined by the discharge or the applications employed, but are excellent as a prophylactic or to prevent a relapse.

In some cases the establishment of asepsis and the compression and protection of a good dressing and bandage are all that is necessary, and for such cases we can recommend the application of a piece of sterilized rubber tissue, cut to the shape of the ulcer, but a little larger, covered by a dry, sterile

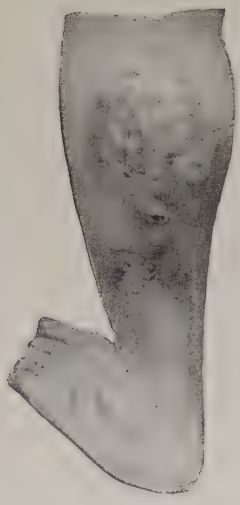
dressing of gauze, with a very thick layer of sterilized cotton and a firm starched bandage outside. This dressing can be left in place for a week. In some cases there is a tendency for the granulations to rise above the level of the skin, and then firm strapping of the leg with strips of adhesive plaster is required. The strapping also draws together the edges of the ulcer and thus assists it to heal. If there is much discharge a dressing must be applied over the strapping.

Local Applications.—In other cases it is necessary to stimulate the granulations by very light applications of nitrate of silver (gr. v to x in ℥j), balsam of Peru, alum, permanganate of potash (gr. v to x in ℥j), nitrate of mercury, sulphate of copper or zinc (same strength), or powdered quinine,

Fig. 19.

Syphilitic ulcer of leg.

Fig. 20.



The same, healed.

salicylic acid, or antipyrine, or a ten to twenty-five per cent. ointment of ichthyol. Ointments of oxide of zinc or boric acid are merely protectives, and suited to cases in which the granulations are fairly healthy. For small ulcers of the same character, powdered subnitrate of bismuth or calomel is useful, forming a protective scab with the secretions. For sloughing ulcers, especially of syphilitic origin, iodoform applied abundantly as a powder is unexcelled; but in some cases it excites a dermatitis, so the surrounding skin should be protected with some simple ointment. Iodoform is excellent, too, in the treatment of tuberculous ulcers, and balsam of Peru is also somewhat of a specific in these cases. (Figs. 19, 20.)

In order to obtain a cure in chronic ulcers it is necessary to cause absorption of the indurated tissues of the base and edges. Moist warm dressings, massage (through a couple of layers of gauze), and incisions are the best methods of treatment. Poultices are unnecessary and unclean, and a heavy

gauze dressing wrung out of any very hot, mild, sterile fluid will produce the same effect as a poultice if kept covered with a very thick layer of cotton and some impervious material like oil-silk or rubber tissue. Hot and cold douches and massage are extremely useful; but it is necessary to make the parts absolutely sterile and free from inflammation before massage is attempted, for septicæmia might follow any manipulation in septic conditions. The pressure of a tin plate or piece of sheet lead cut exactly of the shape of the ulcer, but a little larger, with its edges bent up a little so as not to cut, and secured in place with rubber plaster under an aseptic dressing, has an excellent effect in reducing the thickened margins of an old ulcer. A double series of incisions, crossing like the "cross-hatching" lines of the engravers, hastens the absorption of the induration in chronic ulcers, the effect being to relieve the tension on the parts due to the contraction of the cicatricial tissue, so that the vessels can distend and new vessels can enter. The new granulations which spring up in the incisions will soften the cicatricial tissue on each side, and also provide the way for new vessels to travel into the centre of the indurated area. The parts must be completely sterilized, and the surface of the ulcer slightly curetted, in order to insure this; then the incisions are made. The cross-hatching incisions should be so placed that the distance between them will equal the thickness of the indurated layer (varying from one-quarter to one-half inch), and must be carried entirely through the cicatricial tissue at the base and beyond the edges of the ulcer. When the ulcer is situated over a bone, the knife must be carried firmly down to its surface. Ulcers extending halfway up the leg and around its entire circumference have been successfully treated in this way.

To promote *cicatrization* a very slight touch with nitrate of silver, just enough faintly to cloud the granulations next to the edge of the epidermis, will assist the epithelium to spread over them. Ichthyol favors the epithelial growth. Sometimes the latter remains deficient in spite of all our attempts, or the ulcer may be too large to give any hope of its being covered by natural growth, when some form of *skin-grafting*, as described elsewhere, becomes necessary. If extensive grafting is done, the patient should be confined to bed for some time after healing, until the new skin has become thoroughly well organized, or it will break down as soon as the upright position is resumed. Even after that time a bandage should be employed for months to avoid relapse.

Sinus and Fistula.—A *sinus* or *fistula* is a narrow tract through the tissues, lined with granulations or epithelium. The term *fistula* is generally limited to openings connected with organs lined by mucous membranes, and these openings will be described in connection with the latter. A *sinus* is usually the result of an abscess, and may be formed by the passage-way which has served to discharge the abscess, in which case the latter will be found at its end, or more frequently it represents the shrunken remains of the abscess-cavity itself. The granulations which line the sinus rest upon a layer of cicatricial connective tissue, sometimes of considerable thickness.

Treatment.—In order to obtain a cure it is generally necessary to remove, or at least divide, this cicatricial tissue, by a cut running the entire

length of the sinus on one side, on the same principle as the incision of indurated callous ulcers. The exciting cause of the sinus, whether it be an undrained abscess-cavity, or a foreign body or sequestrum contained in the tissues, must be remedied or removed before a cure can be effected. Then the sinus may be treated by simply packing it thoroughly with gauze or by keeping it distended with a drainage-tube, these simple means usually sufficing when the cause has been removed. If this attempt fails, scraping or cauterization of the walls of a sinus will destroy its lining of granulations, and the contraction of the cicatricial tissue will bring about a cure; but it will generally be necessary to remove the connective-tissue wall as well, or to divide it along one side. Sinuses sometimes become infected with tuberculosis, and are then very obstinate, and they have even been known to undergo changes in their walls resulting in the formation of malignant tumors. The worst forms of sinus are those connected with disease of the spinal or pelvic bones, which may be over a foot in length, and in which the original cause may lie at too great a depth to be recognized and treated.

INFLAMMATION OF SPECIAL TISSUES.

The variations of the processes of inflammation in the different tissues (vessels, bones, glandular organs, etc.) and their treatment will be considered in the separate chapters devoted to them, but it will be convenient to discuss here the inflammations of the mucous membranes, and of the serous and synovial membranes, with cellulitis, erysipelas, and certain of the other surgical infectious diseases.

Mucous Membranes.—It is customary to speak of three kinds of inflammation of the mucous membranes,—catarrhal, suppurative, and fibrinous. The **simple** or **catarrhal inflammation** exhibits hyperæmia, with some exudation of serum, desquamation of the cells, and increased or diminished secretion by the mucous glands. This condition reveals itself by slight redness and swelling and by the changes in the secretion. It may terminate in resolution or go on to suppurative inflammation. In **suppurative inflammation** the exudation contains emigrated cells, which may find their way to the surface, making the secretion cloudy, and even distinctly purulent, or may collect in the substance of the mucous membrane and produce minute abscesses, or cause superficial sloughs of the epithelial cells with the production of ulcers. The clinical appearances coincide with these pathological changes. The ulcerative process may extend into the submucous tissue and result in suppuration there, with more or less complete destruction of the overlying mucous membrane. Finally, there is **fibrinous inflammation,** which results in the formation of layers of exudation, known as *false membranes,* upon the surface of the mucous membrane. These false membranes are made up of fibrin, in fibres and granules, and some free cells, either emigrated leucocytes or mucous epithelia, some normal, others having undergone fibrinous degeneration, and occasionally red blood-corpuscles also. It was formerly customary to distinguish between a so-called *croupous* and a *diphtheritic* false membrane, the former being described as peeling off from the surface of the mucous membrane and leaving it intact, and the latter said to tear off with it the epithelial cells and leave behind it a raw, bleeding

surface. Modern pathologists deny this distinction, claiming that the membrane in every case involves the epithelia, and that they are removed with it, the apparent difference depending not on the form of inflammation or of the false membrane, which are always the same, but upon the structure of the mucous membrane at the point attacked. In both cases the mucous membrane loses its epithelia with the false membrane, and the different appearance in the underlying surface alluded to is dependent on the fact that in some situations the mucous membrane has a well-marked basement membrane from which the cells separate readily without bleeding, and in others it has no such structure, the epithelial cells resting directly upon the submucous tissue, and separating from the latter only with violence sufficient to rupture the blood-vessels. The same variety of inflammation will produce the so-called croupous membrane in the larynx and trachea and the so-called diphtheritic membrane in the pharynx. They therefore limit the term **diphtheria** to the inflammation caused by the *bacillus of Loeffler* (Fig. 9, Plate I.), and the demonstration of its presence should be the determining point in the diagnosis of diphtheritic inflammations. A fibrinous inflammation, resulting in the production of a false membrane, may arise from other causes, but the inflammation should not in that case be called diphtheritic. This is true not only of mucous membranes, but of wounds as well, for in wounds we may have either form of fibrinous inflammation with the production of false membranes. **Chronic inflammation** will show the changes already described, with thickening or ulceration of the parts. In some cases this results in atrophy of the entire mucous membrane, in others in an hypertrophy of the adenoid tissues which are so abundant in them, especially in the pharynx and the intestine.

Inflammation of Serous and Synovial Membranes.—When the serous and synovial membranes are attacked by inflammation the stage of congestion is accompanied with exudation of serum and fibrin from the surface, and the endothelial cells become swollen and detached in large numbers. The serous exudation may be sufficient to fill the entire cavity involved. There is a form of **dry** or **fibrinous inflammation** without fluid exudate, in which the surface of the membrane loses its polish, becoming dry and red, and adhesions readily form wherever the surfaces are in contact. In **suppurative inflammation** pus is produced by emigration, and also by the detached endothelial cells. If fibrin is present, false membranes form on the surface, and the membrane appears to be greatly thickened. At a later stage the proliferating cells invade these layers of fibrin, and they become organized into connective tissue, and new vessels develop in them. Their tendency, however, is to disappear after a time, and the membrane returns to its original condition, unless the inflammation has been very intense, in which case the new connective tissue becomes permanent. In the serous cavities of the pleura and peritoneum this new tissue is of great importance, for the smooth serous surface is destroyed by the false membranes, and when two inflamed surfaces come in apposition adhesions form which may be of great detriment to the organs so connected. In some respects, however, these adhesions are undoubtedly beneficent, as they limit the suppurative exudations and surround foreign material of any kind in the cavity, and thus

prevent extension of the inflammation to the entire cavity. **Chronic inflammation** of these membranes is marked by general thickening of all the layers, the formation of dense connective tissue in the fibrinous membranes, strong adhesions, and sometimes complete obliteration of the cavities, their endothelial lining disappearing entirely. The clinical and other facts of surgical importance will be considered more fully under diseases of the various membranes, such as the peritoneum, pleura, arachnoid, tunica vaginalis, and those lining the joints.

Cellulitis.—Inflammation of the connective tissue, or cellulitis, has been fully described in the preceding sections, for it is from this most common form of inflammation that the general picture has been sketched. It is invariably caused in surgical practice by bacterial infection, and almost invariably results in the production of pus. The infection takes place through a wound, and more often through a minute puncture than an extensive wound, probably because in the latter the tissues are freely divided, the discharges escape at once, and any infection which is present shows itself only in the suppuration of the wound surfaces, not gaining headway enough to invade the surrounding tissues; whereas in wounds which are narrow and deep the micro-organisms develop abundantly in the deeper parts where blood is retained, and manufacture the toxines which impair the vitality of the surrounding tissue, so that the bacteria are enabled to attack the latter with success. An infected wound becomes painful a few hours after it has been received, even if entirely unnoticed at the time, a point of redness develops around it, the part swells and becomes tender to pressure, and these symptoms spread for some distance from the injured point, showing more tendency to extend towards the body in the direction of the returning blood- and lymph-vessels than distally. If the infection has begun in very deep structures, such as the tendon sheaths or the periosteum of the finger, there may be no indications of the commencing inflammation, except pain and tenderness on pressure. The infection attacks the lymphatics, and is carried upward along them to the nearest glands. In some cases the lymphatic vessels themselves are inflamed, and their course can be traced on the skin by the red lines or indurated cords resulting from that inflammation. In other cases the irritant leaves no sign as it passes through the vessels, but the nearest lymph-node will become swollen and tender. In some cases there will be no tendency of the original inflammation to extend beyond its original site, although it may be intense enough to produce an abscess or even extensive sloughing at that point. In others it will begin to advance before the local inflammation seems to have reached the stage of suppuration, and within a few hours a cellulitis which began in some minute wound of a finger may involve the entire arm. In these rapidly spreading cases the subcutaneous tissues are very dense and brawny, feeling as if injected with wax, the overlying skin is red and œdematous, and sometimes of a bluish hue, owing to the great obstruction which exists in the circulation, and the line of advance is usually well marked.

Treatment.—In this type of cellulitis there is little tendency to produce pus at once, but the inflammation is so intense that sloughing often follows, and, as this is the principal danger, immediate incisions are needed, and

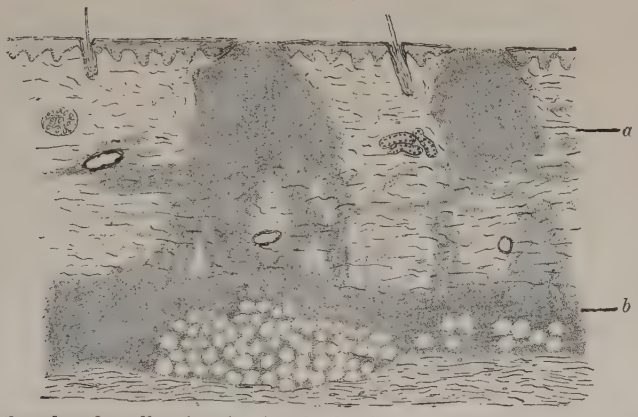
these should not only be made at intervals over the entire area involved, but some of them should cross the advancing edge of the inflammation and extend into the sound tissues for an inch or more in advance of the wave of inflammation. Often these incisions across the advancing margin will at once cut short the further extension of the inflammation.

Incisions for this type of cellulitis, when it involves a considerable area or an entire extremity, must be made about two or three inches in length, and not over two inches apart, being arranged in parallel alternating rows, and they must be carried down to the deep fascia. The main veins of the limb should be avoided, and all incisions should be directed parallel to the long axis of the limb. The hemorrhage is naturally free, but unless the patient is feeble it should be allowed to continue, for it relieves the congestion at once. It can readily be controlled with gauze packing and a firm bandage if it should seem to be too profuse. The part is then to be covered with wet dressings, and, if possible, permanent irrigation of all the cavities is to be established. Less severe cellulitis can be treated with poultices, and incision delayed until abscesses form.

Furuncle. Carbuncle.—A very superficial pyogenic infection of the skin produces merely an acne pustule, which will be described in the chapter devoted to the skin. A *boil* or *furuncle* is a pyogenic infection of the sebaceous glands or hair-follicles, or in rare cases of the sweat-glands, which may spread later to the surrounding connective tissue, causing a circular slough, which is extruded through a small opening in the skin at the centre of the inflamed area. It is usually limited to a spot about an inch in diameter. A *carbuncle* is a similar lesion, in which there is probably more than one point of infection, from which the inflammation spreads and causes rather extensive sloughing of the cellular tissue, the skin being perforated by several of the circular openings and presenting an appearance like a coarse sieve, or as if it had received a charge of bird-shot. Warren asserts that a carbuncle may begin by the infection of a single hair-follicle, working its way downward into the cellular tissue along the column of fat which runs from the latter through the thick derma to every follicle. He thinks it spreads from one cellular interval to another below the skin, and that the peculiar multilocular appearance of the lesion is due to the very dense fibrous tissue which is found between the cellular intervals in those parts of the body in which carbuncle most frequently occurs,—the back and the nape of the neck. (Fig. 21.) A carbuncle may begin as a papule or as a small vesicle surrounded by a dark purple ring, when the vesicle dries, leaving a small black spot. Or it may originate from a pustule or furuncle. The induration and dusky redness of the skin spread usually over an area two or three inches in diameter, but may be four times that width or more. The tissues are at first densely hard and brawny, subsequently becoming boggy when the cellular tissue has sloughed. The skin is œdematous and hard, and circular openings result from sloughing in different parts of the infected area. Through these small openings the sloughing tissue must be eliminated by slow degrees unless assisted by incisions. The process rarely penetrates the deep fascia even in very large carbuncles. Both of these forms of inflammation are found in any part of the skin, but most commonly about the

back of the neck and the shoulders. They occur in aged persons or those who are exhausted by work, and they are often accompanied by the presence of sugar in the urine. The immediate cause is infection from without, by the nails, used in scratching, or through wearing soiled clothing.

FIG. 21.



Section at the edge of small carbuncle of neck, showing two suppurating foci: *a*, skin perforated at two points, otherwise but slightly inflamed in its upper layers; *b*, deeper layers of corium and subcutaneous fat infiltrated with round cells and intensely inflamed. (F. C. Wood, M.D.)

Treatment.—A furuncle or boil is to be treated by a free incision, which may be made crucial if the central slough be large, and should pass entirely through the slough if the incision is made before the latter is detached. It is best to delay incision until the slough has softened and partly separated, treating the boil by hot poultices, unless the pain is very great and the inflammation threatens to spread. It is claimed that the growth of a carbuncle can be arrested by circumscribing it with strips of plaster drawn very tightly across the skin around the edges. Some assert that injections of carbolic acid made into the surrounding parts at the edge of the induration will check the process; but the disease is often self-limited, running a course of a week or ten days, and these statements are, therefore, uncertain. Our best results have been obtained by excision or by thorough curetting. Excision is of necessity limited to carbuncles not over two or three inches in diameter, and to robust patients. The knife must be carried through sound tissues beyond the edges and beneath the bottom of the inflammatory focus, and after waiting a few days to be sure of an aseptic wound without sloughing, the granulating area can be covered with skin-grafts. Healing can thus be secured in two or three weeks. When excision is not feasible the carbuncle can be thoroughly curetted, the curette being passed into small incisions running through the openings in the skin, and the slough removed. The undermined skin should be cut away. By keeping up pressure on the part already treated while scraping out the remainder, the loss of blood can be limited, and a firm dressing will stop all oozing. The most supporting constitutional treatment is to be employed to overcome the weakening effect of the septic element in the disease.

CHAPTER IV.

SPECIAL FORMS OF INFECTION.

ERYSIPELAS.

Definition.—Although it is now pretty generally acknowledged that there is no essential difference between the coccus of Fehleisen, at one time held to be the specific germ of erysipelas, and the streptococcus pyogenes, the affection known as erysipelas is so different clinically from the ordinary infection produced by the streptococcus that we must still describe it separately. Erysipelas is a form of inflammation of the skin, marked by œdema and a dusky flush, which is strictly limited from the healthy skin by a sharp edge. It begins in any part of the body, and advances at one edge while it often subsides at another, thus wandering over the surface. The constitutional symptoms in the milder forms are scarcely perceptible, but in the severer cases they present the profoundest septic intoxication. There are two clinical varieties, phlegmonous erysipelas and facial erysipelas, and we prefer to describe with them the "erysipelatoid" of Rosenbach.

Phlegmonous Erysipelas.—In this form, which is most frequently found upon the extremities in connection with ulcers or cellulitis, but may also appear on the trunk or head, the skin of the part becomes faintly reddened, then œdematous, the rosy hue giving way to a dusky-red flush, the skin being apparently increased to two or three times its ordinary thickness, and becoming dense and brawny. The edge of the affected area is sharply distinguished from the healthy skin by the color and the œdema. The disease progresses in a solid mass, and, although the edge may be very irregular, outlying spots are very rarely seen. After a time the skin first attacked begins to grow pale again and the œdema disappears, the only trace of the inflammation left behind being the desquamation of the epithelium and the falling of any hair growing upon the part. Often, however, the inflammation of the skin is accompanied by a cellulitis, which results in the formation of extensive sloughs and abscesses, although the skin itself seldom sloughs even when this complication is added. The patient complains of heat, weight, and, finally, intense burning pain in the part, but in some cases there is no pain. The disease is ushered in by a chill, which may be very severe, followed by a sudden and great rise of temperature, often reaching 105° to 106° F. (40° to 41° C.). The inflammation may progress steadily or by sudden leaps, every extension being marked in the latter case by chills and another rise of temperature. The fever is of the septic type, with sudden elevations and depressions, the former sometimes not being accompanied by any visible spread of the inflammation. In these severe cases the patient soon becomes delirious or somnolent, the latter indicating per-

haps the severer form of the septic infection. The urine is loaded with albumin, and the bacteria are found in it. The patient may fall into a typhoid delirium, muttering, picking the bedclothes, with involuntary movements of the bowels and the bladder, and die comatose. But even patients who are so ill as this may recover. In milder cases the temperature does not rise above 100° or 101° F. (38° or 39° C.), there is no delirium, and the inflammation is readily controlled by treatment. The disease usually runs its course in ten days or a fortnight, but often lasts five or six weeks if the patient's strength holds out. Aside from the cellulitis and nephritis, there are few complications of erysipelas, for the formation of abscesses elsewhere, and the occurrence of lymphadenitis and phlebitis, must be charged to the cellulitis, as well as the occasional septic bronchitis and pneumonia or meningitis. In simple erysipelas the lymph-glands are not generally infected, although they become so if cellulitis is also present; yet it has been claimed by some that their enlargement is a pathognomonic sign. The development of internal complications, known as metastatic inflammations, may be accompanied by a subsidence of the external symptoms. In cases of erysipelas of the scalp, a meningitis or septic phlebitis of the sinuses of the brain may result from direct extension of the inflammation inward along the veins of the diploe which communicate with the internal vessels. The local sequelæ of erysipelas are a chronic œdema due to blocking of the lymphatic vessels, which may result in elephantiasis; and an impaired vitality of the skin, with a tendency to eczema or ulceration. The cellulitis may result in extensive cicatricial contraction, and the other complications may leave the usual results.

Facial Erysipelas.—The so-called facial erysipelas differs from that just described only in severity. While it has long been acknowledged that erysipelas elsewhere must in every case arise from the inoculation of an open wound, in the case of the facial form this has been contested up to very recent times. The truth of the theory has now been admitted even in this case, although it is seldom that such a point of entrance can be demonstrated. This is not strange when the numerous concealed cavities (nose, throat, ear, etc.) in lymphatic connection with the face are taken into consideration, for a breach of surface might easily exist in them without discovery. Facial erysipelas is further distinguished by the benign character of its course and symptoms in most cases and by the frequency with which some individuals are subject to its attacks. The color of the affected skin remains a rosy pink, the œdema is slight, often barely sufficient to close the eyes when their lids are affected, the temperature rarely rises over 100° F. (38° C.), and the progress of the disease is brief and apparently self-limited, running its course in a week or ten days, and often confined to a very small area. Severer attacks, however, are not infrequent, and some cases are as severe locally and constitutionally as erysipelas in other situations, and especially dangerous, because of the proximity to the brain, and the greater liability of sinus-phlebitis or meningitis. Even the mild forms of the disease are occasionally very obstinate, continuing for weeks and even months, and making a slow progress over the entire head and well down to the chest over the neck. Some persons may have several attacks in a year, apparently

brought on by exposure to cold, but undoubtedly marking the fresh infection of some chronic open lesion in the mouth, ear, or air-passages, naturally taking place whenever the vital resistance of the individual is depressed by any cause.

Erysipelatoid Lymphangitis of Rosenbach.—The "erysipelatoid" disease described by Rosenbach is due to a special micro-organism, growing like the cladothrix, supposed to be a mycelium-producing fungus. The disease resembles the light cases of facial erysipelas clinically, although it is almost invariably found upon the hands, and is probably a lymphangitis. It is most often seen in persons engaged in handling meat, and especially fish, in the market or kitchen, and is probably associated with some peculiar form of early decomposition in these substances. The point of infection can generally be found in some slight scratch or abrasion, or a hang-nail. Beginning from this as a centre, the infection spreads slowly over one finger, and over the dorsum or palm of the hand and wrist, but seldom extends for any great distance. It is marked by a rosy flush, with sharply limited edges, although there is little or no œdema. It heals at one side and spreads in the way characteristic of erysipelas, but exceedingly slowly. There is usually little pain, although in some cases a rather severe burning sensation is felt in the skin, and general disturbance is absent, the temperature seldom reaching 100° F. (38° C.). The disease seems to be self-limited, and runs its course in from ten to fifteen days, gradually fading out, first in the oldest parts, finally at the advancing edge. This form of infection is undoubtedly the same as that known to the older generation as a "run-around," although this name was also given to a vesicular inflammation, while in the true erysipelatoid no vesicles or pustules are ever produced, and after recovery there is seldom, if ever, any scaling of the epidermis.

Treatment.—Isolation.—The first essential in the care of any erysipelatous inflammation is to isolate even the milder cases from any possibility of spreading to persons with wounds or ulcers, infants, and parturient women. Even the mildest cases of facial erysipelas, occurring in individuals who have had the disease so often as to consider it of no greater importance than a cold in the head, are capable of exciting the most vigorous septic form of the disease if inoculated in others who are more susceptible to the poison. In these mild cases, occurring in families in which there are no such especially disposed persons, an absolute quarantine is not necessary if due care is taken to avoid actual contact with the affected individual, to keep the inflamed part well covered, to disinfect the hands thoroughly after changing the dressings, and to destroy the latter by fire. In the virulent cases, however, no precautions can be too great, and the attendants must watch their own hands with the greatest care in order to avoid infection through some unnoticed lesion. Any one having a wound or an ulcer should abstain from actual handling of the patient, for the infection is one of the most powerful and insidious known.

Local Applications.—The milder cases, especially the *erysipelatoid* of Rosenbach, appear to be self-limited, and would probably recover without any treatment—a fact which makes it difficult to estimate the value of the various methods of treatment which have been recommended. There ap-

pears, however, to be sufficient reason to believe that astringent applications, such as a strong solution of acetate of aluminum or a twenty-five per cent. ointment of ichthyol, will check the spread of the disease, and even hasten its resolution. Strong antiseptic solutions, such as 1 to 20 carbolic acid or 1 to 1000 bichloride of mercury, appear to have no greater power over the disease to offset their disadvantages in the way of local irritation and the danger of poisoning. More severe, but uncomplicated, cases are treated upon the general principles of reducing inflammation and by certain special efforts to reach the germs developing in the skin or to limit their spread. The parts may be dressed with strong antiseptic solutions, applied either cold or very hot, and the surface of the skin has been scarified by some surgeons in order to obtain increased absorption of the germicide. It cannot be said that the results of this treatment are very much better than those obtained with milder applications, such as those just mentioned.

Limiting Compression.—Some success is said to have been achieved by painting the skin a short distance from the advancing edge with contractile collodion, so as to obtain a constriction of the tissues as the collodion dries which will be sufficient to shut off the vessels and lymph-spaces of the skin, and so hinder mechanically the spread of the disease. Strips of adhesive plaster have also been employed in this way. It is obvious that the most that can be accomplished by such measures is a partial closure of the avenues of infection, and, while the use of the plaster deserves further trial, it must not prevent us from taking more vigorous measures.

Scarification.—The best effects of the scarification and germicide applications already spoken of are seen when the treatment is limited to the advancing edge and the healthy skin just beyond it, a zone of scarification about an inch in breadth being made on the healthy skin about half an inch distant from the nearest sign of inflammation. The incisions should be about one-sixth of an inch apart, and should be crossed obliquely by another set, making a diamond-pattern. Applications of 1 to 1000 bichloride are made to this belt and to the advancing edge. The necessity for anæsthesia during the scarification is a serious drawback to the method.

Parenchymatous Injections.—Some surgeons practise injections of 1 to 20 carbolic acid or 1 to 1000 bichloride of mercury solutions into the skin just beyond the advancing edge, small quantities being injected at each point and a complete line of the injection being drawn across the front of the advancing inflammation. It is said that the treatment is efficacious, but it is very painful, and it is necessary to use dangerous quantities of either drug, in most cases, on account of the extent of the disease. The method would seem to be justifiable only in cases in which the disease is limited in extent, but threatens to be very virulent in character. In both these methods there exists some danger of a spread of the disease by the scalpel or by the needle, and every possible precaution must be employed to prevent it.

General Treatment.—The greatest difficulty to be met, however, is the fact that in the severe cases there is such prostration that the patient has not sufficient strength to bear very vigorous measures of treatment, and the

general support of the powers of resistance seems to be of more importance than any local treatment yet devised. Even in the mild facial form of erysipelas the patient should at once be confined to his room, or even to bed, in order to secure perfect rest, while the most nourishing and easily digestible food, with a suitable allowance of stimulants, should be ordered; the digestion, and especially the intestinal evacuations, should be regulated and assisted, and such tonics prescribed as seem best suited to the patient's need. The most generally useful tonics are iron and quinine. While we cannot endorse the so-called specific action once claimed for the tincture of the chloride of iron given in large doses, there can be no question that relatively large doses (fifteen to thirty minims), given every three hours, or even oftener, do have in some cases a stimulating effect which cannot be altogether explained by the amount of alcohol thus consumed, and which may possibly be due to the exciting effect upon digestion. But these large doses soon disorder the stomach and tend to produce constipation, and must be discontinued. Quinine is a rapidly acting and powerful stimulant, and, in doses of three grains given three times a day, supports the nerve-centres, and, to a certain degree, probably holds the temperature in check, although its supposed power to check pus-formation cannot be proved. The kidneys are to be carefully watched, and large amounts of fluids administered in order to produce diuresis and encourage them to throw off the poison. The skin may be made to assist the kidneys by encouraging a moderate amount of sweating by a daily alcohol-bath and warm covering. If cellulitis develops, it is to be treated in the usual manner, and so with the other complications.

It has long been known that an attack of erysipelas has a curative effect upon certain conditions. Thus, ulcers take on a healthy action, chronic inflammations clear up, and malignant tumors have even been observed to disappear, after such an attack. Erysipelas has, therefore, been intentionally inoculated in the attempt to produce these effects, and occasionally with success, but the method is dangerous on account of the uncertain and uncontrollable nature of the disease, and has been abandoned in its simpler form. The use of the toxines or antitoxines produced by the germs has, however, been lately introduced for the treatment of malignant disease. (See page 114.)

MALIGNANT ŒDEMA.

The *bacillus* of malignant œdema (Pasteur, Koch) resembles the bacillus anthracis, but the straight rods are more slender (3 micromillimetres long and 1 micromillimetre thick). They produce spores in the body, and they are sometimes found in motion, having flagella. Usually two or three are joined together, forming straight or curved lines, but long chains are also found. It is decolorized by Gram's method. The germ will not grow unless oxygen is excluded. It can be cultivated in agar-agar, gelatin (which it liquefies), or coagulated serum of the blood at the temperature of the body, or even much lower, down to 18° C. Its growth is accompanied by the production of an offensive gas.

It has been proved experimentally that one attack creates immunity, and that immunity may be conferred by injections of the toxines.

This bacillus causes the disease known as malignant œdema in some of the lower animals, and has been found in some cases of a peculiar infectious gangrene in man, compelling us to separate these cases, some of which were undoubtedly included under the head of hospital gangrene by older writers, from the ordinary severe septic inflammations. This disease has been variously described as *gangrenous emphysema* and *traumatic* or *spreading gangrene.* As the bacillus which causes it is anaërobic, the disease is found only in connection with injuries, such as compound fractures, which give an opportunity for deep inoculations protected from the air.

Symptoms.—After a severe lacerated and contused injury of this nature, a dusky bronze hue appears in the skin near the wound and rapidly extends, so that in a few hours it may involve the entire extremity. We have seen it begin from a lacerated wound in the popliteal space of a young man and involve the thigh and entire trunk in twenty-four hours. The color is due to deep hemorrhagic extravasations, and gradually changes into the darker and mottled discoloration characteristic of gangrene. The part becomes hard, brawny, and œdematous, and subcutaneous emphysematous crackling is felt, showing the presence of gas in the tissues, which sometimes extends into apparently healthy parts. If the patient survives long enough, the usual necrotic changes of moist gangrene take place. Extreme prostration accompanies the disease, which is most often found in persons of depraved constitutions.

Treatment.—Immediate high amputation presents the only hope for the patient. We have had a case terminate in recovery after amputation at the shoulder, the disease having attacked the arm.

ANTHRAX.

The disease properly known as anthrax was formerly called **malignant pustule, malignant carbuncle, splenic fever,** and **wool-sorter's disease** (Fr. Charbon; Ger. Milzbrand). It is caused by the *bacillus anthracis* (Davaine, Pasteur) (Plate II., Fig. 22), which is one of the largest of the specific pathogenic microbes, and was one of the earliest to be detected. It is a straight rod, from 5 to 10 or even 50 millimetres long and about 1 millimetre thick, without power of motion, and multiplying in living tissues only by segmentation, although it produces spores in dead culture media. The bacillus is killed by a temperature of 132° F. (56° C.), but the spores are among the most resistant known. It is easily cultivated in the usual media, and liquefies gelatin, producing characteristic colonies. It is supposed by some to grow in soil or manure and thence make its way into the herbivora, and from their bodies, either living or dead, other animals and man may take the disease. Anthrax is much more common in the United States than was formerly supposed. Anthrax may be acquired by infection through the outer coverings of the body, or through the respiratory or the digestive tract. In the latter cases lesions of the internal organs are produced by spores penetrating the mucous membranes, but these lesions are described in the works on practice of medicine. The intact epidermis is a complete protection against the germ, and it can enter only by inoculation of an open wound. Man is most likely to be infected by hides, by the hair

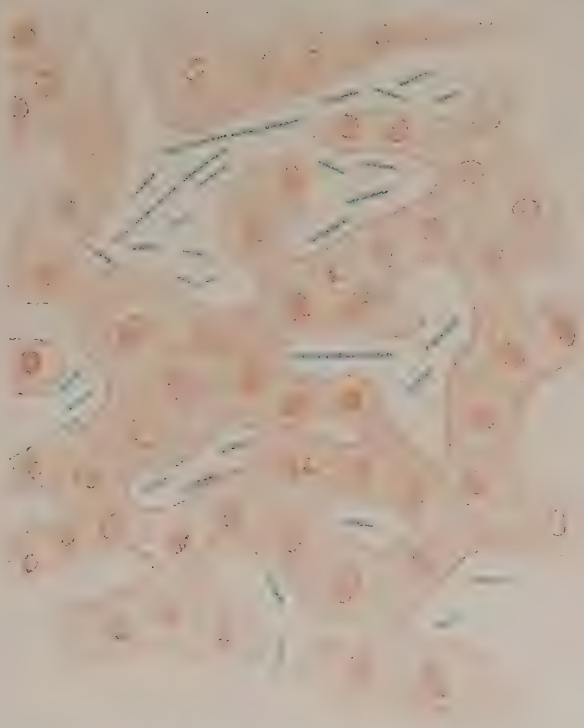
or wool of diseased animals, or by an insect bite or sting, and upon exposed portions of the body—the hands and face.

Symptoms.—When inoculation of the skin has occurred, two distinct forms of inflammation result, the localized carbuncular form and the diffuse œdematous form. The **carbuncular variety** begins with the appearance of a minute red spot at the point of inoculation, which soon develops into a vesicle containing clear or bloody serum. This in turn dries up, leaving a small dark purple or black spot in the skin surrounded by a zone of slight inflammation, shown by a rosy tint of the skin and the formation of minute vesicles. These changes take place in from twenty-four to forty-eight hours, but may develop more rapidly. The inflammatory zone spreads slowly in a centrifugal direction into the healthy skin, while towards the centre the vesicles dry and collapse, and the rosy pink grows gradually darker to a deep red, soon becoming dusky, and finally as dark as the centre. The central necrotic spot is always depressed below the level of the surrounding skin, and it usually remains dry or with a merely serous discharge, as the bacillus is not pyogenic. The ordinary signs of inflammation, such as pain, swelling, and congestion, are absent, the process being that of an acute necrosis of the part affected. In some cases, however, there will be some pain, œdema, and redness, and even lymphangitis. As a rule, the infected spot is about an inch in diameter or less when it is brought to the notice of the surgeon, and in twenty-four hours it will double in extent. Even when there is no pain or other sensation at first, pain is apt to begin after forty-eight hours, when a local œdema appears, which is sometimes rather extensive. The bacillus can be found in this œdematous tissue as well as in the serum of the vesicles. At this time general infection is evident from the rising temperature, due to the absorption of the toxines. Great mental anxiety is felt, which subsides into a somnolent state, and the patient soon succumbs to a typical septicæmia, often with diarrhœa and occasionally albuminuria. The temperature is rarely high, and the worst cases often show the least elevation. If recovery takes place, the temperature usually returns to the normal quite abruptly on the second or third day. Occasional instances of spontaneous recovery have been noted, the inflammation remaining local and the adherent slough being slowly thrown off, the delay depending upon the fact that suppuration never occurs in a pure anthrax inflammation, a mixed infection with pyogenic germs being necessary in order that pus may be produced. The mortality varies greatly with the situation of the primary lesion, for one-fourth of the cases die when the disease attacks the head or trunk, only one-eighth when it is on the upper extremity, and only one in twenty when the lower extremity is involved.

The **œdematous form** is even more dangerous, instances of recovery being very rare, even with vigorous treatment, and almost unknown spontaneously. In this form there is a sudden appearance of a tense œdema, spreading in all directions, with very slight discoloration of the skin, and without the sharp margin which is so characteristic of erysipelas. The lack of the deep bronze color may serve to distinguish it from malignant œdema, but sometimes only a bacteriological examination can decide between the two.

PLATE II.

FIG. 22.



Bacillus anthracis in the capillaries of the liver. (F. C. Wood, M.D.)

FIG. 25.

FIG. 23.

Bacillus mallei. (F. C. Wood, M.D.)

Bacillus tuberculosis. (F. C. Wood, M.D.)

In some cases local patches of gangrene appear on the skin, with the formation of blebs. The pain is not always severe, and at first the constitutional reaction is slight, but the temperature soon rises, and the usual signs of septicæmia develop, with rapid and great prostration.

Treatment.—Carbuncular Form.—In the first twenty-four or forty-eight hours after the appearance of the lesion it remains strictly local, and a general infection can be avoided by immediately cutting out the entire area of skin affected, with a liberal allowance of the healthy skin about it. The wound will then heal like an ordinary wound, and the patient recover. In the **œdematous form** of the disease, also, excision of the parts first affected with cauterization of the wound will sometimes effect a cure, if the disease is not too extensive; but, as a rule, operative treatment will be impossible. Injections of carbolic acid in a solution of water and glycerin (1 to 10) may be made into the surrounding tissues in order to limit the growth of the bacillus, but even this will be difficult because of the large area to be surrounded by the injection and the consequent danger of carbolic poisoning. General supporting treatment will be necessary. The infection of anthrax takes place, as a rule, through the blood-vessels, the internal capillaries being finally blocked by plugs formed of the rapidly growing germs which thrive in the blood. Lymphangitis and adenitis are not common unless there be a mixed infection with pyogenic germs as well, but in some cases the glands enlarge, and it has been recommended to remove them when the primary lesion is excised. Recently a series of thirteen cases has been reported from Von Bramann's clinic, many of them of the severest type of the disease, all of which recovered practically without treatment, the part infected being simply elevated and covered with blue ointment, the patient being kept in bed and vigorously stimulated. Von Bramann was led to this mode of treatment by the observation of Müller that, about the time when the surrounding œdema developed, the bacilli in the primary lesion had entirely lost their virulence and were innocuous, the remaining symptoms being due only to their toxines. He therefore concluded that man was refractory to the anthrax bacillus and with a little assistance his tissues would resist the germs.

GLANDERS.

Glanders is also known as farcy or equinia (Fr. Morve; Ger. Rotzkrankheit), and is prevalent in horses and mules. It is also, but rarely, observed in man, being contracted from these animals. It is caused by the *bacillus mallei* (Loeffler, Schütz) (Plate II., Fig. 23), a rod-shaped microbe, somewhat shorter and thicker than the tubercle bacillus (2 to 5 micromillimetres long and 0.5 to 1.4 micromillimetre thick), motile, multiplying by segmentation—and, according to some, by spores. It is easily killed by ten minutes' exposure to a heat of 131° F. (55° C.), or five minutes in 1 to 20 carbolic acid or 1 to 5000 corrosive sublimate. It grows in the usual media, making white or yellow thread-like colonies. The bacillus is a true parasite, living only in animals, but it can remain alive in the dry state for long periods, so that dried secretions may be dangerous, although few bacteria can be found in the nasal discharge.

Equine Varieties.—In the horse the disease appears in several forms. *Acute glanders* causes a necrotic inflammation of the mucous membrane of the nose, suppurative cervical adenitis, and rapid septicæmia. *Chronic glanders*, with the same lesions but a more chronic course, is marked by ulcers in the nose, destroying even the bones, large cervical abscesses from the inflamed glands, and metastatic foci in the lungs or other internal organs, and also in the muscles and joints. Another form is known under the name of *farcy*, the disease beginning in the same way, but with the addition of metastatic foci in the skin, which may break down and form extensive ragged ulcers, or may not break down so extensively, but a general enlargement of the lymph-nodes may take place. Acute septicæmia may develop even in the chronic form and cause sudden death.

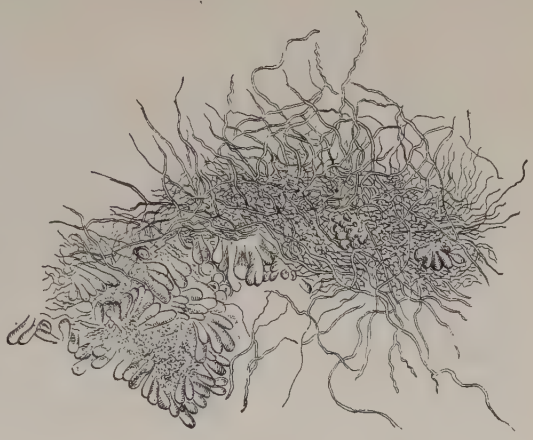
Symptoms.—The usual point of entrance of the infection is the nasal mucous membrane, but it also occurs elsewhere, and it has been experimentally produced by rubbing the cultures on the skin, through the hair-follicles. In man the symptoms and course of the disease depend entirely upon the seat of infection. If it is external, a soft nodule forms in the skin and cellular tissue, which suppurates and produces a ragged ulcer with undermined edges. The ulcer may remain localized and even heal. More commonly the nearest lymphatic glands enlarge at once, for the disease spreads by means of the lymphatics and the bacteria are not found in the blood-vessels. Abscesses form in the glands, further metastasis occurs, and secondary foci may develop in any organ of the body. If infection takes place through the internal organs the disease may closely resemble acute miliary tuberculosis or typhoid fever in its general symptoms, and the diagnosis may be uncertain until an external focus appears. When, on the other hand, there are numerous external foci without any general symptoms, the disease is frequently mistaken for syphilis or local tuberculosis. If the nasal mucous membrane is primarily involved, and in man this is not so invariably the case as in the horse, nodules appear and form ulcers, which may destroy the entire nose, as well as the hard and the soft palate, even in so short a time as a week. The constitutional symptoms also vary; in some a condition of acute septicæmia develops at once, in others the signs of a general infection are absent, even although the glands are affected. Death may ensue in a few days in the acute cases, while in the chronic form recovery may take place after a course of many months. The chronic cases with well-localized lesions are the least dangerous, but acute symptoms have been known to develop suddenly in the course of a chronic case.

Treatment.—But little can be done by treatment except the local removal of infected tissue, and if the local foci are not too extensive they should be excised, or incised and curetted or cauterized, either by the hot iron or by chemicals. In severe cases, however, complete eradication of the disease is impossible. The patient must be quarantined, and all discharges carefully burned. Experiments have been made with a serum containing the toxines (mallein) which is useful for diagnostic purposes, like tuberculin in tuberculosis, and may furnish a means of treatment in the future.

ACTINOMYCOSIS.

Actinomycosis, or "*lumpy jaw*," is a disease produced by the *ray-fungus*, which forms star-shaped masses of mycelium, made up of radiating threads with bulbous extremities, a number of these being generally combined to make a mass about the size of a millet-seed, of cheesy consistency and usually of a bright yellow color. (Fig. 24.) It gains access through some open wound or a carious tooth, and grows in the tissues, which react towards it and surround it by a chronic inflammatory granulation-tissue, often containing giant-cells, but made up of round cells, and closely resembling tuberculous or sarcomatous tissue. This mass continues to grow by the formation of new nodules in its neighborhood and their fusion with the original one, and may continue for some time as a firm tumor and attain considerable size. It soon becomes infected with pyogenic germs, and breaks down, forming a chronic abscess. The disease spreads by direct extension into the surrounding tissues, destroying even the bone, but not invading the lymphatics. In rare cases it may perforate the wall of a vein by ulceration and thus produce an embolus, which will be carried off to form a metastatic focus in some distant organ. The fungus has been cultivated artificially, but with great difficulty. It has been found growing in carious teeth in almost pure cultures without causing any symptoms and without any tendency to spread. On the other hand, a carious tooth infected with it has been known to abrade and inoculate the tongue.

FIG. 24.



Actinomyces or ray-fungus. (After Israel.)

While common in cattle, actinomycosis is rather a rare disease in man, except in certain countries, being perhaps most frequent in Austria. The external habitat of the fungus is not known, but several cases are on record in which the infection was directly associated with the presence of a grain or a beard of rye in the tissues, and its frequent occurrence in cattle, taken together with the fact that the great majority of the cases originate in the alimentary canal, especially the mouth and jaws, or in the respiratory tract, indicates that it is to be found in some of the vegetable foods.

Symptoms.—In man the progress of the disease is best seen in cases of cutaneous inoculation. Here a hard nodule forms in the skin and subcutaneous tissue, and reaches a certain size without pain or any sign of inflammation except congestion of the skin. The nodule often forms an abscess, which slowly perforates the skin and discharges from a small opening a

rather thin white pus containing some of the characteristic granular masses, which under the microscope reveal the fungus. These abscesses closely resemble tubercular cold abscesses, especially in their tendency to burrow in the direction of least resistance or of gravity, and in the formation of long fistulæ. Abscesses in the lung often open externally. When the point of inoculation is in the mouth the nodule becomes infected and suppuration sets in much earlier, and with the suppuration the growth of the fungus appears to be accelerated, so that large tumors are formed about the jaws. Metastasis occurs rarely, but has been found even in the brain. But the internal organs are generally infected directly from the extension of a nodule which forms in the wall of the intestine or in the mucous membrane of the bronchi or lungs and may involve any of the neighboring parts. The fungus finds its way into the respiratory passages by inhalation, sometimes being carried down by a foreign body, such as a grain or an infected carious tooth. A chronic perforating ulcer of the foot, known as "Madura foot," is caused by a fungus closely resembling the actinomyces.

Diagnosis.—The diagnosis of actinomycosis is very difficult, the nodules before breaking down resembling round-cell sarcoma, and later tuberculous or syphilitic tissue, even under the microscope, so that the recognition of the fungus may be absolutely necessary for a diagnosis. Clinically it may be distinguished from sarcoma by its tendency to suppuration, and from tuberculosis and syphilis by the freedom of the neighboring glands from infection. Iodide of potassium affects actinomycosis as well as syphilitic disease. The prognosis depends upon the site of the infection and the stage at which treatment is begun. Left to itself it appears to be invariably fatal, and when the internal organs are involved thorough surgical treatment is impossible. When it is possible to eradicate it completely by operation, recovery may follow.

Treatment.—When the focus is seen before it has broken down, it should be thoroughly excised, like a malignant tumor. If an abscess has formed, it should be widely opened, and its walls excised if possible; if not, it must be treated like a tuberculous abscess, with thorough curetting and cauterization. Injections of a 1 to 20 solution of carbolic acid may be made into any tissues which cannot be removed. The general health must be improved by every possible means. Cures in cattle and even in man have recently been reported to have followed the internal administration of large doses of iodide of potassium.

TUBERCULOSIS.

Tuberculosis is an infectious disease caused by the tubercle bacillus, marked locally by circumscribed inflammatory nodules, with cheesy degeneration of the centre of the mass and the production of peculiar cells, and having a tendency to invade the lymphatic channels, and secondarily the blood, resulting in similar inflammations of distant parts. The cause of the disease is the *bacillus tuberculosis* (Plate II., Fig. 25), discovered by Koch in 1881, a slender bacillus, sometimes slightly bent or curved, 2 to 6 micromillimetres long and 2 micromillimetres thick, without power of motion. It has not been found elsewhere than in living animals, and appears to be

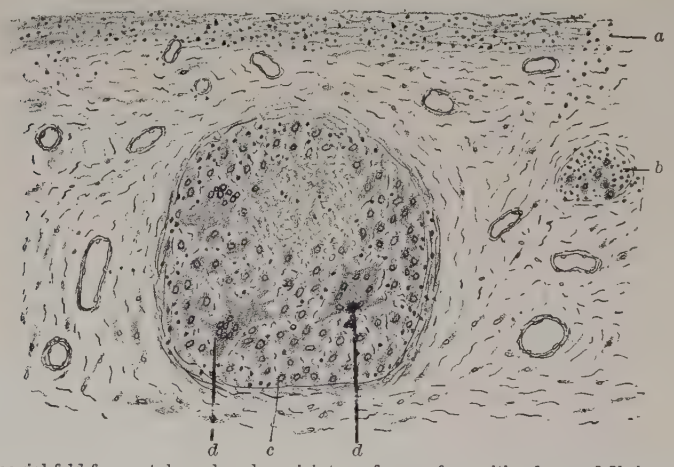
a typical parasite. It can be cultivated in solidified blood-serum, or in a mixture of glycerin and gelatin, at a temperature of 98° F. (37° C.), forming white or gray opaque colonies, looking like thick, round, wrinkled crusts on the surface, not liquefying the serum. It can be inoculated in the animals usually employed, but some are very resistant, as, for instance, the goat. No spores have yet been demonstrated. This bacillus can grow either with or without oxygen. It is difficult to demonstrate, but stains well with the Ziehl carbolic-fuchsin solution or by Gram's method. The tubercle bacillus is very sensitive to changes in temperature (even 108° F. (42° C.) arresting its growth), and it can be killed by any of the ordinary germicides, and even by direct sunlight.

The usual *seat of its inoculation* in man is the respiratory or intestinal mucous membrane, although it may invade the skin if there is a wound or an ulcer, and it may also begin its attack in the genito-urinary organs. A period of incubation of three weeks is said to intervene after inoculation of the skin before any lesion is seen. Wherever its point of entrance, its tendency is to invade the lymphatic vessels and glands and from them spread to the rest of the body. It finds its way into the general circulation, and if large numbers enter the blood it may make a simultaneous attack upon many organs in the form known as acute miliary tuberculosis. If the bacilli in the blood are not numerous, on the other hand, they may die out. Any organ may be infected, especially if injury or other cause produce a disturbance of the local circulation, and so form a point of lessened resistance. The principal parts liable to tuberculosis which are of surgical interest are the superficial mucous membranes (mouth, pharynx, nose, conjunctiva), the skin, the bones and joints, the lymphatic glands, the peritoneum, the kidneys, bladder, urethra, testicles and prostate, and the female genitals.

External Infection—Tuberculous Ulcer.—The lesion will vary with the manner of its origin, whether it is caused by inoculation from the surface or from within through the blood or lymphatic vessels. In the former case an external wound or abrasion of some degree appears to be necessary, and such a wound forms an ulcer; or, if the inoculation be at the bottom of a puncture, it produces a nodule which breaks down into an abscess and results in an ulcer by sloughing of the skin covering it. Inoculation of the skin may take place in wounds made by broken vessels used by phthisical patients for expectoration, by dressing wounds with handkerchiefs containing their sputa, or by direct infection of wounds from the mouth. Whether in skin or in mucous membrane, the ulcer is easily distinguished. The base is covered with a white, thin slough or with pale, small or exuberant, and flaccid granulations. The edges are irregular as if worm-eaten, undermined, bluish pink in color, and usually surrounded by a faint inflammatory areola. The discharge is serous, with a few pus-cells. In the mucous membranes the color of the base is apt to be rather yellow than white. There is never any trace of induration, although there may be a soft thickening about the ulcer. The microscopic examination of such a lesion discloses a general round-cell infiltration with few typical tubercles or giant-cells, ulceration progressing too rapidly to allow of these characteristic formations.

Lymphatic Infection—The Tubercle.—Very different is the lesion when the bacillus has penetrated the lymphatics and reached the nearest lymph-nodes. The infected node becomes swollen and hyperæmic. The cells multiply and produce rounded cells, from two to six times the size of the leucocytes, with indistinct outlines, a pale, granular protoplasm, and a rather small, ovoid, vesicular nucleus, causing them to resemble epithelial cells, and hence they are named epithelioid. The epithelioid cells are found under other circumstances, but are so common in tubercle as to be fairly characteristic. In some cases of true tubercle, however, they are absent. Within the circle of epithelioid cells is often found one or several giant-cells. Outside of them are seen very numerous small round cells, like the lymphocytes commonly found in lymphatic glands, forming the outer boundary of the *tubercle*, as the entire mass is called, and infiltrating the neighboring tissues. (Fig. 26.) These cells are supposed to come from emigration of white blood-corpuscles, as in any ordinary in-

FIG. 26.



Section of synovial fold from a tuberculous knee-joint: *a*, free surface with a layer of fibrin and leucocytes; *b*, small tubercle with leucocytes and epithelioid cells; *c*, large tubercle; *d*, giant-cells. (F. C. Wood, M.D.)

flammation. In some instances, however, no epithelioid cells or giant-cells are formed, and the tubercle is simply made up of the round cells, and is known as a "*small round-cell tubercle.*" The epithelioid cells multiply, two or more nuclei being frequently seen in them, and it is supposed that from them by division of nuclei without division of cell-body are formed the giant-cells. It is also possible that the giant-cells may be formed by fusion of several cells in one, or even by the multiplication and fusion of the endothelial cells of a small blood- or lymph-vessel, the characteristic appearance being produced by the cross-section of such an occluded vessel. The giant-cells are irregular in shape, generally more or less elliptical in section, with star-like projections, the centre formed of granular protoplasm, which appears to be already degenerated, surrounded by numerous nuclei near the border arranged somewhat radially. Between the cells is a more or less evident reticulum, supposed to be the remains of the fibres of connective

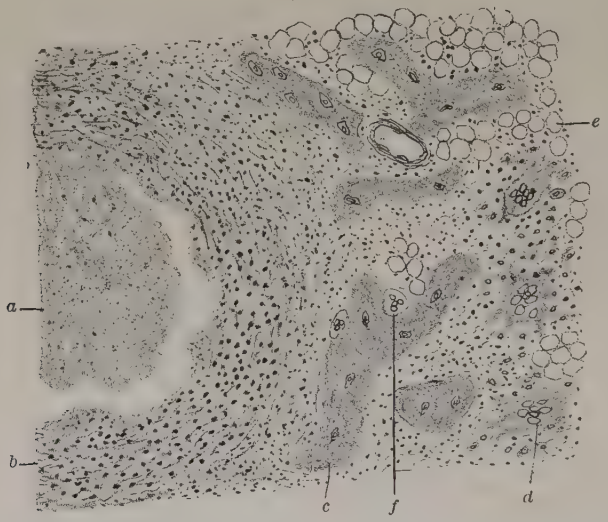
tissue, which holds the cells firmly in place and binds the entire structure to the surrounding tissues. The gross appearance of such a tubercle is that of a gray, pearly, somewhat translucent nodule, becoming opaque and white as it grows older, without blood-vessels, firmly attached to the surrounding tissues, and quite firm or even hard to the touch. A tubercle grows by additions to its periphery up to a certain size, and then certain degenerations occur, undoubtedly due to the poison of the bacilli, for such small masses would not undergo these changes simply from a diminished blood-supply. The nodules seen by the unassisted eye are made up of several tubercles fused into one, the degeneration having progressed farthest in those at the centre, but the boundaries between them can generally be traced. There is apt to be some production of fibrous tissue around the tubercle, which may finally entirely encapsulate the mass. To this new-formed fibrous tissue are to be ascribed the spindle-cells often seen scattered through the tubercles. The bacilli in the tubercles of man usually lie in the epithelioid cells or giant-cells, or between them, but they are often very difficult to demonstrate, as they do not stain readily. The cells at the centre of the tubercle may gradually lose their moisture and form a hard, cheesy mass, or even calcify by the deposit of lime salts in the caseous material. In other cases a thin, serous pus is produced at the centre of the tubercle, and by constant enlargement and the conglomeration of neighboring tubercles the typical cold abscess results. If such an abscess forms in a lymph-node, the fibrous capsule of the latter is the only tissue able to resist its progress, and the gland becomes converted into a sac of pus.

Tuberculous Infarction.—Somewhat similar is the process when the bacilli reach any part of the body through the blood-vessels, for they occlude a small capillary as if by an embolus, and thence spread into the tissues supplied by it, forming tubercles, beginning in the walls of the blood-vessels, the entire mass being wedge-shaped, like an infarct. The structure of each tubercle is similar to that just described. This is the usual process in the *bones*, in which the tuberculous infiltration destroys the softer parts, and the rest of the bone remains for a long time as a soft sequestrum, penetrated in all directions by tuberculous granulation-tissue. (Fig. 27.) Wherever the tubercles are free to grow they produce a soft, spongy tissue resembling granulation-tissue, and sometimes known as tuberculous granuloma, and the budding processes of this tissue spread into the surrounding parts.

When *serous* or *synovial* membranes (*peritoneum*, *tunica vaginalis*, *pleura*, the *joints*) are involved, tubercles are formed in the same manner, but the granulations are of a very faint pink color, or white and gelatinous-looking, owing to the diminished supply of blood caused by the dense infiltration of the tissues by the round cells. Typical tubercles are found, and the membranes appear greatly thickened, owing to the constant deposition of new layers of fibrin on their surfaces, each layer in its turn becoming infiltrated with tubercles, so that there is a constant formation of new tissue under the stimulus of the infection. The *cartilages* of the joints are detached, and look worm-eaten, from the encroachment of the tuberculous granulation-tissue, and when they are penetrated the growth extends into the bone.

In other cases the disease begins in the bone and affects the joints secondarily. In the peritoneal and the pleural cavities, abscesses may be formed, limited by adhesions. Or thick layers of fibrin may be deposited, producing adhesions and obliterating the cavity. Or, finally, large quantities of serum may be exuded by the inflamed membrane, and but little fibrin. Similar varieties in the process are to be observed in the synovial membranes of the joints.

FIG. 27.



Tubercular osteomyelitis of head of tibia: *a*, tuberculous abscess partly filled with thick pus and detritus; *b*, fibrous capsule formed around abscess; *c*, trabeculæ of bone; *d*, giant-cells in the bone marrow; *e*, fat-cells in the marrow; *f*, osteoclast causing absorption of bone. × 100 diameters. (F. C. Wood, M.D.)

Suppuration.—Whether or not the tubercle bacillus is capable of exciting the formation of pus is not settled as yet, but the weight of authority is in favor of this theory. Prudden, however, found that in order to obtain true phthisical cavities in rabbits afflicted with pulmonary tuberculosis it was necessary to inject the streptococcus into the trachea—otherwise no breaking down took place. **Tuberculous abscesses** are called **cold abscesses**, because they are without any of the ordinary signs of inflammation, unless pyogenic infection has occurred, and the pus is usually sterile or merely a pure culture of the tubercle bacillus. The pus or puruloid fluid contained in these abscesses is thin, white, and full of flakes of cheesy matter. Microscopically it contains fat-globules, broken-down cells, cheesy masses, and a few leucocytes. Some suppose that a double infection is necessary to start suppuration, but that when pus is once produced its formation might continue even though the pyogenic germs died through the influence of the toxines. Tuberculous lesions readily become infected and suppurate, but, even when fully exposed to the air, they do not appear to be subject to very virulent infections—erysipelas, for instance, being rather rare even in the most neglected. If a tuberculous abscess, however, becomes infected and is not allowed free drainage, a sharp rise of temperature ensues. Cold abscesses are lined with granulation-tissue, the so-called

pyogenic membrane, which is merely a layer of tuberculous tissue. They tend to spread in the direction of least resistance, usually settling through the cellular spaces in accordance with gravity, softening the connective tissue, eroding bones, but generally sparing nerves and large blood-vessels, which may often be found strung across their cavities, the surrounding tissues having been dissected away. The skin over these abscesses is very slowly involved, sometimes remaining unaltered for years. When it is attacked it turns purple, sloughs at some point, and, when the pus is discharged, a typical tuberculous sinus is formed. Sometimes these abscesses disappear by inspissation and absorption of the pus, even when very large.

The *symptoms* of tuberculosis are considered in connection with the various organs affected.

Treatment.—The treatment of tuberculous lesions is constitutional, germicidal, or mechanical. The tissues resist tuberculous infection in varying degrees, and in some parts of the body, and in some individuals, this resistance is very great. It is accomplished by the formation of cicatricial tissue around the tubercles, shutting off their blood-supply by compression and opposing their advance by its fibrous nature. This resistance can be greatly increased by measures directed to improving the general condition of the individual, such as rest, exercise, fresh air, abundant and good food, and general hygiene, including residence in a suitable climate. Many persons will recover without any other treatment. Cod-liver oil, various tonics, and sometimes an allowance of alcoholic stimulants, assist.

Sclerogenic Method.—Locally the formation of fibrous tissue may be favored by injecting a ten per cent. solution of chloride of zinc into the tissue (Lannelongue), a method which appears to have given very good results in the hands of French surgeons. The theory upon which this method is advocated is that the tubercle is arrested in its growth by the production of cicatricial tissue around it. The punctate use of the thermo-cautery has also been successful, acting in a similar way.

Operative.—The foci may be extirpated mechanically, either by simple incision and curetting or cauterization, or by complete excision. Joints are resected, tuberculous foci in bone chiselled out, and tuberculous organs, such as the kidney or the testicle, removed. The amputation of a limb may be necessary.

Tuberculin.—When Koch introduced tuberculin it was hoped that we had obtained a selective agent which could be injected anywhere in the body and would reach the tuberculous foci by circulating in the blood, and destroy the germs by its indirect action upon the tissues in which they lay. But it was soon found that a favorable effect could be obtained only in a few cases, and its use has been almost entirely abandoned.

Finally, and this method appears to promise most in the future, we may attempt to destroy the bacillus in the focus itself. Various substances have been employed for this, but the most generally used are iodoform and balsam of Peru. The balsam of Peru is used in full strength.

Iodoform Injections.—The iodoform is employed in a ten per cent. emulsion with glycerin or olive oil, or in solution in ether. The fluid is injected

into the focus or cavity to be treated in as large amounts as possible, but generally only a small quantity can be forced into the solid masses. Only in the case of cold abscesses is an overdose to be feared, and it is safe to use fifteen grains of iodoform at a time. The iodoform-ether has the disadvantage of causing great pressure from the formation of vapor at the body temperature, and the emulsions are quite as effective. We have also used iodoform-vaseline (ten per cent.) liquefied by heat for injection. The injection should be carried out with full asepsis, the needle or canula and syringe boiled, the skin disinfected, and the solution sterilized by repeated heating in the Arnold sterilizer for from five to ten minutes at a time; or the iodoform can be washed in 1 to 1000 bichloride of mercury solution, and the glycerin sterilized separately by heat, for long-continued heating or a high temperature decomposes the iodoform.

Bier's "Constriction."—The effect of these various methods in a limb can be increased by constriction with a rubber band, as suggested by Bier, so as to induce a venous hyperæmia, which acts either by the direct effect of the venous blood, or by retarding the circulation and causing an accumulation of the toxines of the tubercle bacillus in the parts, and the consequent poisoning of the germs themselves.

Scrofula is a term applied to a certain constitutional state in which there is an unusual tendency to tuberculous infection. It is marked by a fair complexion, rather abundant but flabby adipose tissues, thin red mucous membranes, and enlarged lymphatic glands; or by a dark complexion, with prominent red or pale lips, a very transparent waxy skin, and unusually marked blue veins. Both types are liable to anæmia, lassitude (although in some instances there is a certain spasmodic energy), a tendency to catarrhal inflammation of the nose and throat (often associated with the lymphatic enlargement in these regions, or adenoids), and a generally lowered power of resistance to infectious diseases. Although the majority of these individuals succumb to tuberculosis sooner or later, the close resemblance between many of their traits and those of hereditary syphilis in its mild forms cannot be denied. The term scrofula may be antiquated, but the clinical picture is practically useful, indicating, as it does, a generally weakened power of resistance.

LEPROSY.

Lepra, Elephantiasis Græcorum, Leontiasis.—Leprosy is an infectious disease, probably caused by the bacillus lepræ, characterized by cutaneous eruptions and by inflammatory infiltrations in the skin, mucous membranes, peripheral nerves, lymph-nodes, and certain viscera.

The *bacillus lepræ* is a slender rod, 5 micromillimetres long and 0.4 micromillimetre thick, closely resembling the bacillus tuberculosis, even in staining, but more easily decolorized. It is found in the local lesions and in the blood during the last stages of the disease, but not in the natural secretions or urine, although it occurs in the muco-purulent discharge of the ulcerated mucous membranes. It has been observed only in man, and all attempts at isolation and cultivation have failed, as indeed have attempts at direct inoculation with material from ulcers, except in one doubtful case. The disease, however, is undoubtedly contagious by close and long contact,

such as using the same clothes and table-utensils. Some persons are evidently immune, and resist infection even under the most intimate association with lepers. It is doubtful whether it can be acquired by sexual intercourse. Like tuberculosis, the disease is not directly hereditary, but a predisposition to it may be inherited. Leprosy is found in the inhabitants of about one-quarter of the world and in all climates.

Symptoms.—It appears in two forms, the tubercular, affecting chiefly the skin, and the anæsthetic, affecting the peripheral nerves, but the two forms are also found combined. There is no definite primary point of infection to be found in most cases, although it must always exist. There is an *incubation period* of from six weeks to nine months, with various prodromal symptoms, such as intermittent fever, epistaxis, pruritus, and vague nervous sensations. In the **tubercular variety** the first eruptions are dark-colored papules, which may come and go, but finally persist as soft tubercles from the size of a pea to that of a walnut. These appear on all parts of the body, being most marked upon the face and the anterior surface of the forearms. On the face the great thickening of the skin produces the characteristic leonine expression. These tubercles may ulcerate, producing very deep and extensive ulcers. The lymph-nodes enlarge and suppurate, and the hair falls out in the affected areas of the skin. The mucous membranes appear to be attacked before the skin, as indicated by epistaxis, rhinitis, and salivation, and ulceration may make great ravages in the nasal and oral cavities. The genito-urinary membranes usually escape.

In the **anæsthetic variety** bullous and erythematous eruptions appear on the skin, followed by dark-colored rounded macules, which tend to fade in the centre and spread at the edges. These spots are hyperæsthetic at first, becoming anæsthetic as they grow pale. The anæsthesia is selective, the tactile sense being preserved while the sense of pain is lost, and often there will be a loss of perception of heat while that of cold is preserved, or *vice versa*. The eruptions are located on the lower extremities, on the backs of the arms, and also on the trunk and face. The mucous membranes are similarly affected, and the anæsthesia of the pharynx interferes with swallowing. The changes in the nerves are similar to those of a neuritis, the ulnar and peroneal nerves being especially affected. There are neuralgic pains, growing worse at night, and the nerves are thickened and tender. Paralysis and muscular atrophy and contractures may result, especially in the interossei, the muscles of the arm, the deltoid and pectoralis, and the muscles of the leg and face. Plantar ulcers may form, and other trophic changes are seen in the rarefaction of the phalanges, the fingers and toes losing entire phalanges in this way by absorption, without any ulcerative process. The disease is incurable, although there are cases which recover spontaneously even after considerable deformity has been produced.

Treatment.—The treatment can consist only in isolation, hygiene, and local treatment of the lesions. Chaulmoogra oil internally and local applications of gurjun oil seem to influence the disease favorably. Tonics are required, and above all a favorable climate. Nerve-stretching is useful for the pain of the nervous form, and is reported to have been followed by disappearance of the local lesions.

TETANUS.

Lockjaw (Ger. Wundstarrkrampf; Fr. Tétanos).—Tetanus is an infectious disease caused by a special bacillus and its toxines, affecting the nervous system, and characterized by persistent contraction of the voluntary muscles, with paroxysms of aggravated spasm, and, occasionally, local paralysis. The *bacillus tetani* (Fig. 28), discovered in 1885, by Nicolaier, is a slender rod, growing in chains, often enlarged at one end by the formation of a spore, giving it the characteristic drumstick appearance, motile, found in garden-earth, street-dust, the excrement of healthy animals, and elsewhere. It grows at ordinary temperatures, rapidly at 98° to 102° F. (37° to 39° C.), being anaërobic, forming a fir-tree-shaped stab-culture in gelatin, and liquefying the medium in one week. It takes all the stains. The spores resist a temperature of 176° F. (80° C.) for one hour, but are killed by five minutes' exposure to 212° F. (100° C.) moist heat. It produces several toxines, all of which excite spasms, and one causes paralytic symptoms as well. The sterilized toxines produce the same effects as the living bacillus, even including the occurrence of a *period of quiescence* or *incubation* after their introduction, and *the typical regular spread* of the disease, which always begins at the point of introduction, unless the poison be thrown directly into the circulation or into the peritoneal cavity, when general symptoms are produced at once. The period of incubation is not due to retarded absorption, for if a minute quantity of the toxines be injected into the end of a rat's tail, amputation done much higher up at the end of forty-five minutes fails to save the animal. Their intense virulence is indicated by the fact that an experimenter accidentally pricked himself in the hand with a hypodermic needle which was simply moistened with the toxine, and in three days developed the ordinary symptoms. The poison enters the circulating blood, and is carried equally to all parts of the body, but the spasms do not begin at once in all parts, and appear first in the muscles nearest the point of infection. If the dose inoculated be very small, the spasm may be limited to that group. The best theory offered to explain this peculiarity is that of Brunner, who assumes that the toxines create a state of irritation in the nerve-centres, but that the explosion of nerve-force is not produced unless the corresponding peripheral nerve-terminations are also subjected to the local effect of the poison as it spreads through the tissues by diffusion or lymphatic conveyance from the point of inoculation. It has also been proved that an intact sensory and motor nerve connection is necessary, spasm not occurring if the sensory reflexes are prevented from reaching the centres, or if paralysis of the muscles is produced by section of the motor nerves.

Fig. 28.

Bacillus of tetanus. (F. C. Wood, M.D.)

The presence of the toxines in the blood causes the production in the serum of an antitoxine which has the power of conferring immunity from tetanus when injected into another animal, and even of assisting in the resistance to the disease when already developed. The tetanus bacilli are

rarely found in the tissues, for Kitasato has shown that they disappear from the point of inoculation within ten hours, and they have very seldom been discovered in the blood or other parts. They appear to need the assistance furnished by the presence of sloughs, foreign bodies, or the bacteria of suppuration in order to live, tetanus being most frequently seen in connection with wounds in which these conditions are furnished, such as gunshot wounds and frost-bite.

The disease is found in nearly three-quarters of the cases to have originated from wounds of the hands, feet, and lower extremities, and in one-tenth of the cases from those of the head and neck, but it is probable that the liability of wounds of these parts is due to their greater exposure to injury and to infection. Age and sex make no difference in the liability, but it is said that the negro is more likely to contract the disease, and that it is more common in hot climates, facts which may also be dependent upon other causes, such as unsanitary habits of life. The symptoms following thyroidectomy, which closely resemble tetanus, have nothing to do with that disease, depending upon some toxic materials circulating in the blood. Tetanus is frequently seen in the new-born, as the result of infection of the umbilical wound, and is occasionally met with in the puerperal woman, in which case it must not be mistaken for eclampsia. It is impossible for tetanus to develop without inoculation through a wound, although the latter may be concealed in the mouth or elsewhere, the cases reported to have followed eating the flesh of animals which had died of the disease not being beyond criticism. The bacillus of tetanus does not prevent primary union, and the wound may be healed soundly before the disease breaks out. The pathological changes produced by the disease are not fully known, the appearances formerly supposed to indicate an ascending neuritis and myelitis not being conclusive, for the principal change observed is capillary congestion, which may be only a passive result of the circulatory disturbances.

Symptoms.—The disease begins from one to twenty days, usually about one week, after infection, with pain and stiffness in the back of the neck and in the muscles of the jaw. In some cases these are preceded by paralysis or spasm of the muscles near the seat of infection, but this limitation is rare in man, and is not easy to produce in the experiments upon animals, general symptoms having usually begun at the time the patient comes under observation. Examination of the muscles affected shows that they are in a state of chronic contraction, with occasional paroxysms of intense spasm. These symptoms spread to the adjoining groups of muscles, and in severe cases soon involve the entire body, and it has been observed that in this extension the parts on the same side of the body as the point of infection are first and most severely attacked. If the muscles of the back are chiefly affected, the body is bent backward into an arch, a condition known as *opisthotonus*. If the body is bent forward, it is called *emprosthotonus*, if sideways, *pleurosthotonus*, and if it remains perfectly straight and rigid, *orthotonus*. The spasms are caused by the least sensory reflex, such as the slamming of a door, the touch of a finger, even a draught of air, or attempts to swallow. In the intervals the patient lies as still as possible, to avoid exciting another spasm. Priapism is sometimes present. The muscles of

the face are so contracted as to produce a sort of grin, in strange contrast with the weary, half-shut, drooping lids. This contraction may remain permanently to a slight extent after recovery. The temperature rises in severe cases to an extreme degree, even 110° F. (43.3° C.) having been observed, while 105° F. (40.5° C.) or more is common, and after death it sometimes rises a degree or more higher, 113.5° F. (45.5° C.) being recorded. In mild cases there is little or no fever. The elevation of temperature is to be ascribed partly to the violent muscular action, and partly to the direct effect of the toxines upon the heat-centres. Sweating is observed in the paroxysms. The pulse in mild cases follows the temperature, growing rapid and feeble as the strength fails; but in the severe cases it is very weak and rapid from the onset, probably being reduced by the direct effect of the toxines upon the circulation. The mind is clear, although apprehensive, and sleeplessness is the rule. Great emaciation sets in, from exhaustion and the difficulty of feeding the patient through the fast-closed jaws. In some cases there is a reflex spasm of the œsophagus and of the glottis. In fact, death by asphyxia during a paroxysm is not unusual, and can generally be ascribed to this cause (as is proved by the fact that tracheotomy usually gives relief), although in some instances it may be due to the tonic contraction of the respiratory muscles and even of the diaphragm. The muscular action is very intense and painful; in fact, ruptures of the muscles or of the tendons are not uncommon.

Prognosis.—The cases vary in their severity, the acute cases, with a short incubation period and rapid generalization of the symptoms, being apt to terminate fatally, while the so-called chronic cases, in which the disease usually develops slowly and some time after infection, run a course of from four to twelve weeks, and not infrequently recover. Death has been known to occur within a few hours of the infection, and frequently takes place within one day after the first symptom. If the patient survive for ten days or a fortnight, recovery may be expected. The mortality, as based upon the military records up to 1871, varies from eighty-three to ninety-three per cent.; but it is probable that it is less at present, with our better understanding of the means for securing asepsis in infected wounds.

Facial, Paralytic, or Hydrophobic Tetanus.—One peculiar variety of tetanus deserves separate consideration,—namely, that which follows wounds in the distribution of the cranial nerves, the so-called facial or head tetanus, also known as hydrophobic or paralytic tetanus. It is marked by the occurrence of paralysis in the muscles most affected (usually those supplied by the facial nerve) and by reflex spasm of the œsophagus, which is in some cases so marked as closely to resemble hydrophobia. The disease begins with contracture of the muscles nearest the injury, on both sides of the face if the wound is in the middle line, otherwise unilateral, followed by spasms, gradually extending to the muscles of the other side, while those first affected become paralyzed. If the infection is severe the symptoms of general tetanus follow, with the usual fatal result, but the mortality of these cases is only fifty-eight per cent., showing that, as a rule, the disease is milder. The paralysis is easily overlooked if not sought for, and in some cases there is

none. The instances of marked œsophageal spasm are rather rare. The paralysis is to be considered a sign of virulence in the infection, and depends upon a paralyzing agent among the toxines of the tetanus-bacillus. It is always limited to the part first affected, although the spasms generally extend to the rest of the body.

Treatment.—The most important recent addition to treatment has been the discovery of the apparent curative effects of the tetanus antitoxine by Tizzoni and Cattani. The protective serum is obtained by injecting animals with the pure cultures of the germ until they become immune, and drawing blood-serum from them. This is employed in hypodermic injections. Several instances of cure apparently due to the serum have been reported, but the majority of these have been of the chronic form of tetanus, so that the usefulness of the method is still uncertain. Other treatment avails little. The first necessity is thoroughly to disinfect any suppurating wound which may be found, to remove sloughs and foreign bodies, and to secure proper drainage. Chloroform or amyl nitrite may be given by inhalation to palliate the paroxysms, and their effect will be increased by morphine in one-fourth to one-half grain doses hypodermically. In mild cases chloral hydrate and bromide of potassium in from fifteen- to twenty-grain doses up to the limit of safety have proved useful. Curare has been recommended, but is dangerous and not of marked benefit. Nourishment must be maintained by a catheter passed into the pharynx through the nose, as it will be impossible to open the jaws. It is generally necessary to move the bowels with enemata and to draw the urine. The patient must be confined in a dark, quiet room, under the care of one or two persons only, and every noise or sudden motion must be avoided, as well as any unnecessary handling of the body. Verneuil has suggested wrapping the entire body in cotton and confining it in splints. The former operative treatment by neurotomy or nerve-stretching or amputation was based on an erroneous theory, which ascribed the disease to reflexes from wounds or scars, and has been abandoned. Amputation may still be practised when the thorough disinfection of the injured limb is impossible or other conditions demand it, and operations are usually well borne by such patients if performed early. Tetanus is best treated by prevention, and, fortunately, the asepsis of modern surgery appears able to prevent it, probably as much by rendering wounds unfavorable to its development as by actual destruction of the germ.

HYDROPHOBIA.

Lyssa, Rabies.—Hydrophobia is an infectious disease affecting the nervous system, marked by spasm of the pharynx and glottis, excited by attempts at swallowing, followed by general muscular convulsions and death. It originates in animals of the dog and wolf tribe, but is communicable through the saliva of any rabid animal when inoculated in a wound of any of the warm-blooded animals. Although there can be no doubt of its bacterial origin because of the period of incubation, the infectiousness, and the possibility of destroying the virus by the ordinary germicidal methods, the specific microbe has not yet been discovered. The mad dog shows his disease by a prodromal state of affection, then by paroxysms of rage, followed

by dulness, moroseness, and a disposition to avoid company. He becomes unable to swallow, but never shows any fear of attempting to do so; in fact, he tries by every means to assuage his thirst up to the end. He appears insensible to pain, and wanders about with drooping head and saliva dropping from his mouth until he is exhausted, when he rests awhile, and then resumes his wanderings until death ensues from exhaustion in from four to six days. He is not apt to seek victims, rather avoiding them, but bites if annoyed or thwarted. His bite on unprotected skin is dangerous, but even then about one-third of the victims escape the disease by their constitutional powers of resistance. If the bite is given through clothing, the latter may prevent inoculation with the saliva. Inoculation may, on the other hand, take place without a bite, by the mere contact of the saliva of a rabid animal with an open wound.

Symptoms.—In man there is usually an *incubation period* of six weeks, but in some cases this has been as short as one day, and in others even eight months have passed before symptoms appeared. The supposed instances with a longer incubation period, lasting even for years, are uncertain. There may be prodromal symptoms, such as nervousness and pain in the scar of the wound, which is generally healed by that time. The incubation is said to be shortest in wounds on the head, longer in those of the hands, and still longer in those elsewhere. The patient feels difficulty in swallowing, becomes anxious, decided spasm of the pharynx and glottis sets in, and general convulsions follow, with delirium, exhaustion from suffering, and death. Death is inevitable, no case of recovery being on record.

Treatment.—It is said that fully two-thirds of the patients bitten by rabid dogs fail to develop the disease if the bite is thoroughly cauterized or excised, but the whole subject is so uncertain that no figures are of value. In any doubtful case, the animal which gave the bite should be kept alive in order to ascertain whether it is rabid. The treatment is to be carried out upon the lines suggested for tetanus, but it is only palliative. Pasteur has introduced a method of *protective inoculation* which it is claimed would prevent rabies or enable the patient to resist it if administered during the incubation period. Under the stimulus of this discovery the number of reported cases of this rare disease in France has increased immensely, a sufficient indication that all statistics upon this subject are misleading. Even with the best showing the treatment is effective only when applied before any symptoms develop, it often fails even then, and it has dangers of its own, multiple neuritis and even rabies having been observed to follow its use. A protective serum for conferring immunity against rabies has recently been introduced by Tizzoni and Centanni, but its usefulness in man is as yet undetermined.

CHAPTER V.

REPAIR OF WOUNDS—REGENERATION OF TISSUES.

THE reparative powers of the tissues of the human body are considerable, although not comparable with those of the lower animals, in the lowest orders of which the reproduction of an entire limb or even one-half of the body regularly takes place. In order to understand the regeneration of tissue we must first consider briefly the life-history of the cells. A *cell* consists of a mass of protoplasm, generally enclosed in a cell membrane, and containing a nucleus and a nucleolus. The nucleus represents the most vital part of the cell protoplasm, staining most intensely with the various dyes used in histological methods, and having a more granular appearance. The nucleolus is a minute solid spot in the nucleus, appearing to be much more highly refractive.

Cell Division.—When the cell is quiescent the protoplasm appears evenly granular (Fig. 29, 1), but when it is stirred to active life, slender twining threads are to be traced in the nucleus, resembling the coils of the capillary vessels in the glomerulus of the kidney, and perhaps consisting merely of one long thread twisted upon itself. On account of their readiness to take up the dyes used in staining, the threads are called *chromatine threads*. When the cells are about to divide, the chromatine threads are

FIG. 29.

Karyomitosis. (F. C. Wood, M.D.)

seen to arrange themselves about the equator of the nucleus in a rosette or star shape, known as the mother-star. (Fig. 29, 2 to 4*b*. 4*a* is a polar and 4*b* an equatorial view of the same cell.) Some larger granules then appear at the ends of an axis passing perpendicularly through this equatorial rosette, at the poles of the nucleus, and the loops of the threads are directed towards the poles. Gradually these threads become arranged in radiating

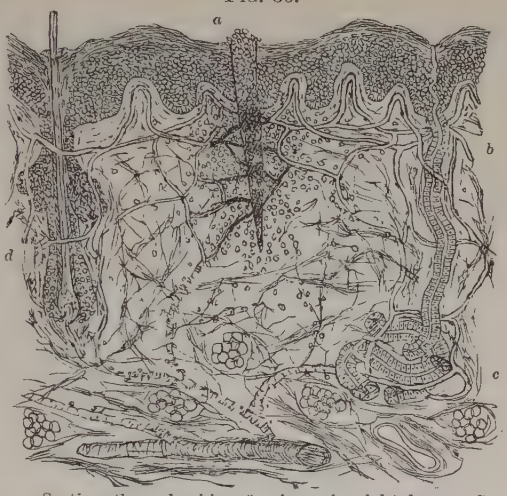
lines, converging at the poles, and then break away from their former connection with the equator, forming a *daughter-star* at each pole, a bright space appearing at the equator. (Fig. 29, 5.) A constriction next appears in the nucleus at the equator, and the nucleus divides into two distinct nuclei, each containing one of the daughter-stars. (Fig. 29, 6.) Simultaneously with this division, or immediately following it, the protoplasm of the cell-body divides in the same place, and thus two complete cells are produced. (Fig. 29, 8.) The chromatine threads lose their rosette arrangement, and gradually become imperceptible as the new cell returns to the quiescent state. This process of cell division is known as *karyokinesis* or *karyomitosis*, from the Greek κάρυον, a nucleus, κίνησις, motion, and μίτος, a thread. (Flemming.) In simple cells like the leucocytes, reproduction may take place by simple fission, a constriction appearing in the nucleus and in the body of the cell in the same plane, and the two dividing without any visible protoplasmic changes, but such a mode of division probably does not occur in the more highly specialized cells of the various tissues. If the karyokinetic action be not very vigorous, the nucleus may divide, but the cell-body remains intact, producing the cells with two or more nuclei so commonly observed.

Every cell reproduces its kind, connective-tissue cells producing connective tissue, epithelial cells epithelium, bone producing bone. It has recently been shown that in the connective tissue the cells may become so quiescent as to be invisible to microscopic examination, only fibres being discerned until some irritation has been applied to the tissues, when nuclei and cells appear in all directions among the fibres as suddenly as if by magic. Grawitz has aptly called these quiescent cells *slumbering cells*. The demonstration of these cells explains the extremely rapid appearance of immense numbers of new cells in tissues subjected to irritation, although large numbers of the new cells are supplied by the leucocytes which emigrate from the blood-vessels, as has been explained in the chapter on inflammation. These emigrating leucocytes take no active part in the restoration of tissue, for the multiplying cells of the tissues alone have that power, but the leucocytes may furnish food for the other cells. The power of restoration is most marked in the connective-tissue cells, which are called *fixed cells*, but it is also active in the cells of the periosteum, bone-marrow, endothelial lining of the vessels, and the various epithelial structures. It is very feeble in the striped muscle cells, and entirely absent in those of cartilage.

Repair of Wounds and Healing by Apposition.—When a wound or "loss of continuity" has occurred in the tissues, the latter retract at once at the point of division on account of their elasticity, and the gap is more or less filled with blood or serum. If no bacterial or chemical irritant is introduced, there are no true inflammatory changes. The divided blood-vessels are occluded by coagulation of the blood in their open ends, and this coagulation extends to the nearest patent branch. (Fig. 30.) The capillaries around the seat of injury dilate slightly, the fixed cells of the tissues become active, dividing by karyokinesis and becoming loosened from their beds, while other new cells are furnished sparingly by the leucocytes. The endo-

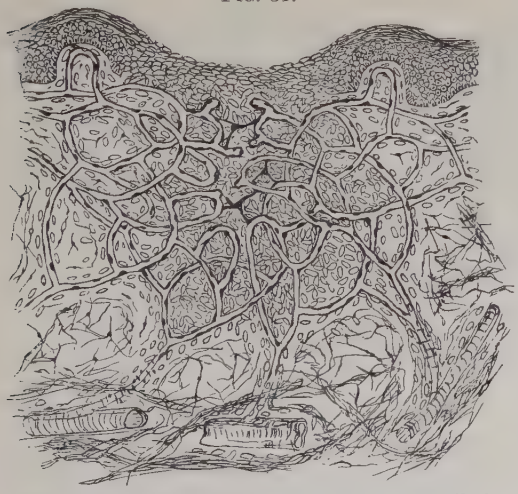
thelial cells of the divided blood-vessels multiply and take an active part in the process. In spite of the slight congestion and the new cells produced, the reaction is much less than that of inflammation. The new cells invade the blood-clot, consuming it and also any foreign matter or any tissue which may have been killed by the injury. From the loops of the occluded capillaries at the sides of the wound spring buds of endothelial cells, which grow like the roots of a tree into the mass of blood-clot and cells, becoming thicker and then hollow as they extend, blood-cells forming in them, and blood entering them also from behind. (Fig. 31.) These advancing endothelial tubes anastomose with their neighbors, and also with those which have started from the other side of the wound, and thus the new-forming tissues are supplied with blood-vessels. (Fig. 32.) It is said that new vessels are also formed by the pre-existing lymph-spaces and by independent cells. Meanwhile the connective-tissue cells have been forming fibres across the clot, and epithelial cells begin to spread over its surface if skin or mucous membrane be involved in the injury. The new vessels disappear, and the new connective tissue forms the cicatrix. (Fig. 33.) This is the process of primary union in a wound in which there is not a marked cavity or a loss of tissue on any of the exposed surfaces of the body, and no matter how closely the edges of such a wound may lie in contact it can heal by no other method. Even the closest apposition of the sides of a wound cannot prevent the interposition of a thin layer of clot and the partial death and absorption of a very thin layer on

Fig. 30.



Section through skin of guinea-pig eight hours after a wound: *a*, the wound, filled with clot, the capillaries thrombosed on both sides; round-cell infiltration; *bc*, sweat-gland; *d*, hair-follicle. (Shakespeare.)

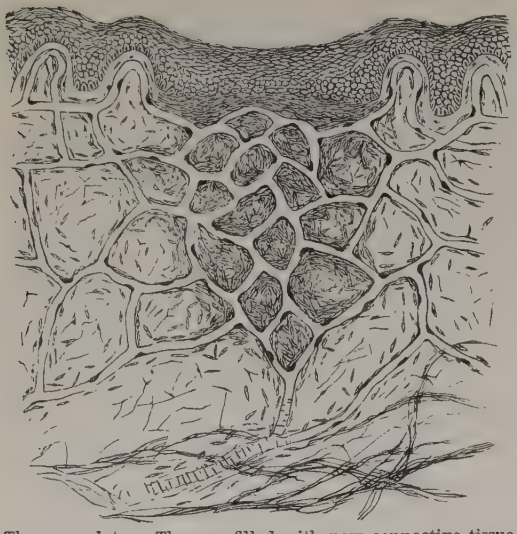
Fig. 31.



The same at a later stage. The clots in the capillaries almost removed, new vessels forming towards the gap, new connective-tissue spindle-cells replacing the round cells. The epithelium has united on the surface. (Shakespeare.)

its surfaces, so that the former theory of union by *agglutination* is untenable, although in some aseptic wounds only careful microscopic examination can disprove it.

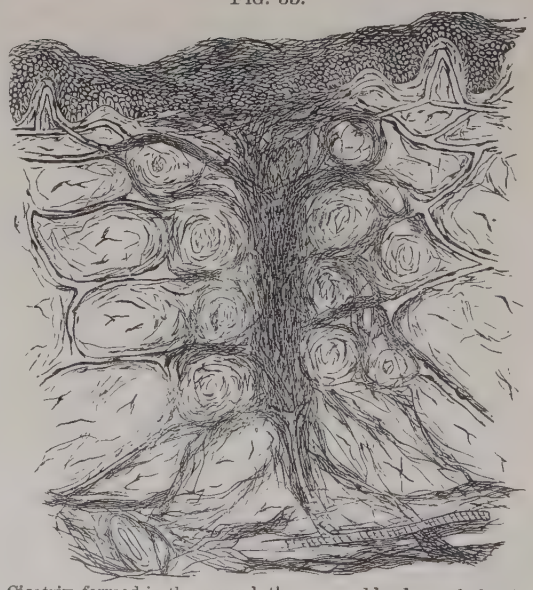
Fig. 32.



The same later. The gap filled with new connective tissue and young blood-vessels. (Shakespeare.)

Healing by Granulation.—When a wide gap has been produced by retraction or actual loss of tissue, healing takes place by granulation, as it is called, a process which differs from that just described merely in the fact that more tissue has to be reproduced. The outpouring of blood and serum, occlusion of vessels, congestion, multiplication of fixed cells, emigration of leucocytes, and production of vascular buds and loops goes on as before. But as the formative changes advance, small, round elevations of a rosy color appear on the new surface, making it look like velvet. These rounded elevations of the healing surface are called granulations. They advance steadily on all sides, filling the gaping wound until the level of the original surface is reached, the new tissue organizing behind them, and contracting as it organizes, so that the space to be filled is daily made smaller by this contraction as well as by the production of new tissue. (Fig. 34.) As the surface is reached the epithelial cells on the edges of the granulating area slowly spread over it, the granulations generally projecting above the adjoining surface, and the epithelium growing over them as they contract again to their proper level. The advancing line of epidermis is visible as a pale pink line, gradually whitening with time.

Fig. 33.

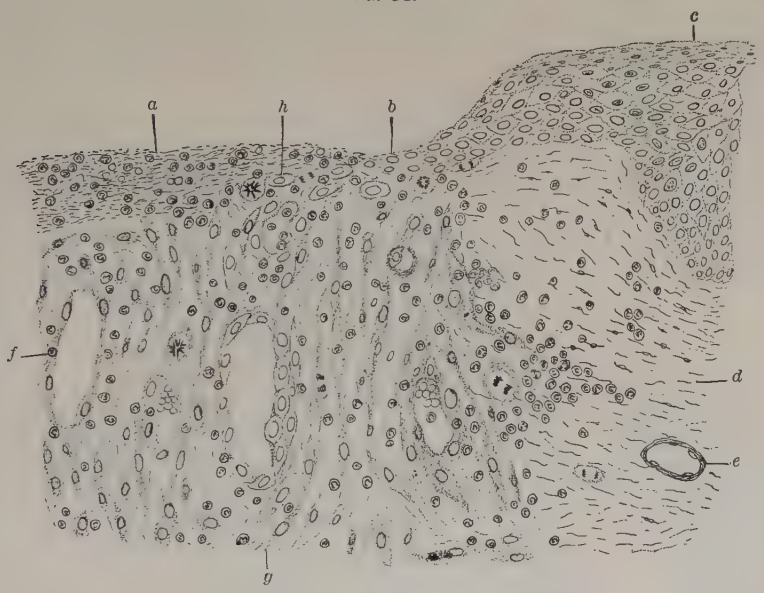


Cicatrix formed in the wound, the young blood-vessels having disappeared. (Shakespeare.)

When a wound has been left gaping, or has been packed until its sides have granulated, rapid adhe-

sion of these granulating surfaces can often be obtained, and septic wounds or abscess-cavities can be closed by taking advantage of this fact and bringing the granulating surfaces together by deep sutures when all trace of sepsis has been removed by the open-wound treatment.

Fig. 34.



Healing of a wound by granulation: *a*, layer of fibrin, leucocytes, and detritus over surface of granulations; *b*, advancing edge of epidermal cells from skin; *c*, skin at edge of wound; *d*, corium with some inflammatory infiltration; *e*, blood-vessel in normal tissue differing in its structure from those in the granulation-tissue; *f*, blood-vessel in latter with a leucocyte emigrating through its walls; *g*, new connective-tissue cells called fibroblasts; *h* points to an epithelial cell, and on either side of *h* are two cells in process of division, showing their rapid growth. (F. C. Wood, M.D.)

Defects of the superficial epithelial surfaces are made up by growth of the cells, and in the glandular organs also there is a growth of the epithelial cells with partial reproduction of the gland-tissue destroyed, as has been observed in the liver and testicle; but this reproduction is seldom complete.

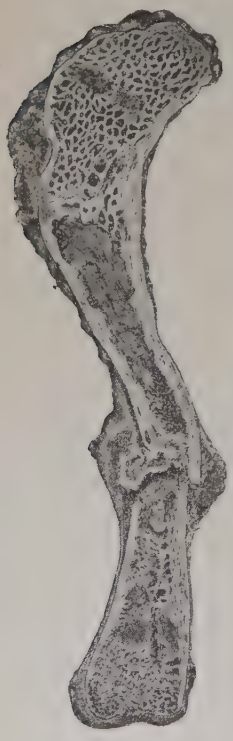
Repair of Tendons.—Repair of *tendons* is accomplished by the growth of connective tissue from the sides of the tendon-sheaths, the tissue of the tendon itself taking very little part in the process. If there is no extravasation of blood into the sheath, the latter collapses where it is left empty by the retraction of the divided ends of the tendon, becomes adherent to the latter, and then forms a band connecting the two ends and permitting of restoration of function, while the collapsed sheath is thickened by connective-tissue growth. More commonly there is an effusion of blood in the sheath, and the clot fills the space between the ends of the tendon, being finally replaced by the production of granulation-tissue, which starts from the inner surface of the sheath and becomes converted into connective tissue.

Repair of Muscle.—*Non-striated muscular cells* have considerable reparative powers, but it is only recently that the power of reproduction of

striated muscular fibres has been proved. The regeneration of the latter is feeble, and it is accomplished by budding from the muscle-fibres themselves, the processes from the latter extending into the granulation-tissue or young connective tissue of the cicatrix, and becoming interlaced with those from the opposite side of the wound.

Repair of Nerves.—It is questionable whether the *nerve-cells* of the gray matter of the brain and cord are capable of reproduction, but the *peripheral nerves* unite completely. When a nerve is divided the peripheral portion degenerates at once. A connective-tissue union is formed between the divided ends if they are not too far apart, a fusiform swelling being produced similar to the callus of a fractured bone. Repair of the nerve-fibre is possible only by growth from the central end, and is preceded by the breaking up of the myeline sheath and axis-cylinder, followed by proliferation and migration of the nuclei of the neurilemma, the sheath and cylinder then disappearing. Nuclei surrounded by protoplasm fill the sheath, being continuous above with the nerve-fibres, and forming embryonic fibres, which become complete, with an axis-cylinder and a myelinic sheath.

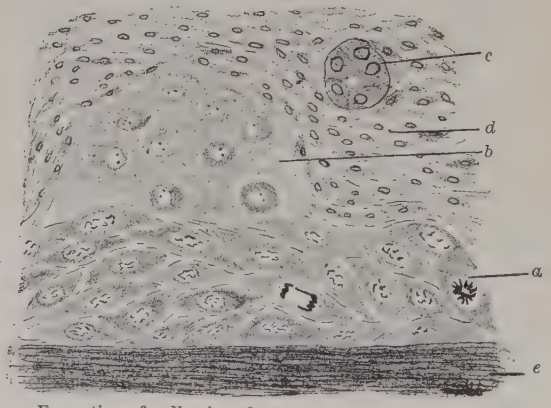
Fig. 35.



Section of fractured clavicle, three weeks after injury, showing internal and external callus.

Repair of Bone.—In the process of repair of the bones after fracture, the blood-clot and exuded serum make a fusiform swelling without definite boundaries, extending into the soft parts, called the callus. (Fig. 35.) That portion of it which is formed by the periosteum and soft parts is known as the external callus, and that which forms from the medullary bone-cavity in the case of fracture of the shaft of a long bone is called the internal callus. The interme-

Fig. 36.



Formation of callus in a fracture seven days old: *a*, proliferating periosteum fibroblasts with mitoses; *b*, newly formed cartilage; *c*, small blood-vessel with swollen endothelium; *d*, granulation-tissue; *e*, a layer of bone which takes no part in the process. (F. C. Wood, M.D.)

diary callus is merely that part between the two which is derived from both sources. The first change observed is the emigration of leucocytes into the

exudation; then the cells of the deeper layers of the periosteum and of the adjacent bone proliferate and form fusiform, stellate, or angular cells, the bone-cells being concerned especially in the internal callus. (Fig. 36.) These cells acquire a halo like cartilage-cells, and the substance in which they lie becomes solid, and is known as the osteoid substance. Near the centre of the callus true hyaline cartilage is produced. These cells are called osteoblasts. Lime salts are deposited in the osteoid substance and

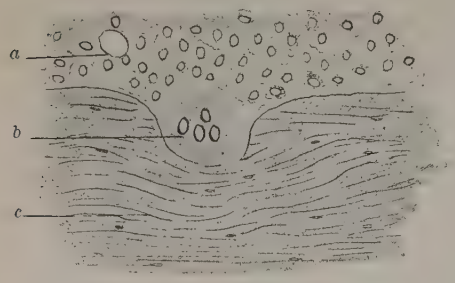
FIG. 37.

Callus from fracture of a small bone, two weeks old: *a*, fibrous capsule of the callus; *b*, trabeculæ of osteoid tissue formed from the periosteum and in the granulation-tissue of the callus; *c*, the shaft of the bone containing the fatty bone-marrow; *d*, new-formed cartilage; *e*, a small fragment of bone which has been pushed into the marrow; *f*, intermediary callus formed from the periosteum and also from the bone-marrow.

cartilage, trabeculæ appear, and the osteoblasts form bone-cells. Haversian canals containing blood-vessels appear, running in different directions from those of the subjacent normal bone. The internal callus thus forms a bridge of bone uniting the ends. The external callus has meanwhile undergone similar changes, and both are altered into spongy bone, the spaces of which are filled by granulation-tissue, with a layer of osteoblasts between it and the bone, which constantly add new bone to the

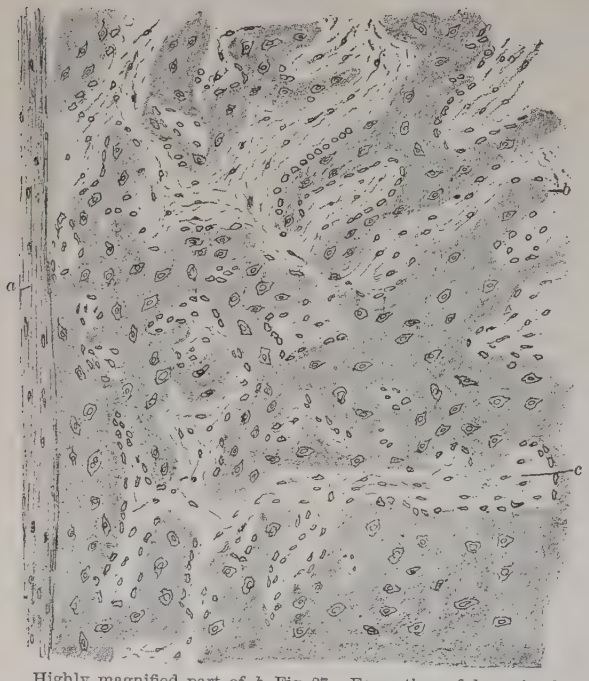
trabeculæ. (Figs. 37 and 39.) As the bone increases in amount the hyaline cartilage disappears, some believing that it changes by calcification and the alteration of its cells into bone-cells. This large amount of callus is called the *provisional callus;* when union is complete it grows smaller, and the remaining portion, known as the *definitive callus,* becomes denser. Associated with the absorption of the callus is the presence of large cells with many nuclei (so-called giant-cells or osteoclasts), which lie in little excavations along the edges of the trabeculæ of bone, making it appear as if they caused the absorption of the bone, although this is not absolutely proved. (Fig. 38.) By this absorption the medullary spaces between the trabeculæ enlarge, and the latter disappear. By similar

Fig. 38.



Osteoclast, highly magnified from *e*, Fig. 37: *a*, bone-marrow with fat; *b*, osteoclast causing absorption of bone; *c*, hard bone. (F. C. Wood, M.D.)

Fig. 39.



Highly magnified part of *b*, Fig. 37. Formation of bone in the granulation-tissue two weeks after fracture: *a*, hard bone; *b*, trabeculæ of osteoid tissue, later to become true bone by deposition of lime salts; *c*, remains of the granulation-tissue. ×100. (F. C. Wood, M.D.)

Fig. 40.

Section of fractured femur, showing re-formation of medullary canal by absorption of internal callus. (Paget.)

means the medullary canal is formed through the centre of the callus (Fig. 40), and the cortical portion of the included broken ends is absorbed, so that it may finally become impossible to locate the point of injury.

Occlusion and Repair of Blood-Vessels.—When an *artery* is ligated, a clot forms at the seat of ligature and speedily becomes penetrated with endothelial cells, produced by the multiplication and emigration of those lining the vessel. Simultaneously with this there is an exudation around the outside of the vessel in which the granulation-tissue is formed, and the latter absorbs the exudate, penetrates the artery where it is ligated, or enters the ends of the divided vessel, and replaces the internal clot. There is also a proliferation of the connective tissue and of the muscular cells of the vessel-wall. After several months the result is a cicatrix, which forms at the point of injury and in which every layer of the vascular wall is represented, although the connective tissue is in the preponderance. Veins are occluded in a similar way. Primary union of the edges of a lateral wound in a vein, and even in an artery, has been shown to be possible in man. Circular suture of the ends of a vessel divided transversely has also been successfully performed. The reunited vessel remains pervious if it is a vein, but becomes slowly occluded by endothelial growth if it is an artery. The union of wounds of vessels is undoubtedly obtained by connective-tissue growth, followed by restoration of the walls in all their elements, and it makes apparently very little difference whether the endothelial surfaces or the surfaces of the adventitia are brought into contact by the suture, although later experimenters prefer the latter, for it is very important that the sutures shall not be exposed in the lumen of the vessel, as a clot would form about them.

CHAPTER VI.

TUMORS.

Definition.—Any swelling may be called a tumor, but the term is generally restricted to the new growths or neoplasms. A neoplasm is a localized growth of tissue out of place, distinct from the tissues about it, and serving no purpose in the economy of the body, although it may be of a structure resembling normal tissue. It is generally held that, with a few doubtful exceptions, a true neoplasm never disappears spontaneously. The general changes of nutrition in the body do not affect the growth of a neoplasm, and a lipoma remains of the same size whether the body loses or gains in fat elsewhere, while a cancer actually grows at the expense of the body. Tumors may press the adjacent tissues aside, being separated from them by a firm capsule, or the cells of the tumor may directly invade the surrounding parts, destroying them or changing them into the same sort of abnormal tissue.

It is very difficult to separate the ordinary neoplasms from certain congenital malformations. A teratoma is a tumor formed of fœtal tissue, independent of the body, but attached to or included in it. These tumors are supposed to owe their origin to causes similar to those concerned in the production of twins, the teratoma representing an abnormal or incomplete twin. We can formulate a complete series from twins to dermoid tumors, the connecting links being the joined or Siamese twins; individuals with incomplete twin bodies or limbs attached to them; individuals with large solid tumors of fœtal structures growing from the sacral region or pharynx (the true teratoma); and, finally, the dermoid tumors and cysts. It is also difficult, often impossible, to distinguish between the tumors and the hypertrophies, for an osteoma is merely an abnormal local growth of bone, and an adenoma a local over-production of glandular tissue. The essential distinction between the two is the fact that the neoplasms do not contribute in any way to the performance of function; the osteoma does not add to the strength of the bone, and the adenoma does not produce active secretions.

Benign and Malignant Tumors.—Neoplasms may be divided clinically into the benign and the malignant. Sarcoma and carcinoma are malignant, all other tumors benign. A benign tumor has no tendency to invade the surrounding structures, and is usually limited by its capsule. The existence of a capsule is indicated clinically by the free motion of the tumor on the surrounding parts. A benign tumor grows slowly, is fairly well supplied with blood-vessels, and does not tend to ulcerate. When it has been entirely removed, by operation or otherwise, it does not return, and it does not form secondary tumors in other parts. It is, therefore, not in itself dangerous to life, but it may become so, on account of its situation,

by interfering with the performance of the functions of important organs. Malignant tumors have all the opposite characteristics: they grow rapidly, they are seldom encapsulated, they tend to invade the surrounding parts, they are poorly nourished and are apt to slough or ulcerate, and they invade the blood-vessels and lymphatics and thus form secondary tumors. On account of these reasons, and by their foul discharges, their interference with the functions of various organs, and a peculiar sort of cachexia, they invariably terminate fatally. But there are some intermediate varieties, tumors otherwise benign which grow rapidly and form secondary tumors, and malignant tumors of slow growth without much tendency to dissemination. Some tumors which have been apparently benign may suddenly begin to grow rapidly and become malignant. These cases are explained by assuming that a change has taken place in the tissues of the tumor, and that they have taken on the malignant form of growth and lost their innocent character. Malignant tumors are commonly called **cancer**, but some would restrict that name to carcinoma.

Classification.—The pathological classification is based on the structure of the tumors, and it is followed in the nomenclature of new growths, the general termination *oma* signifying a tumor, and being preceded by a Greek prefix describing the tissue of which it is composed. Thus we have osteoma, chondroma, fibroma, adenoma, and even angioma, signifying tumors of bone, cartilage, and fibrous, glandular, and vascular tissue. The terms sarcoma and carcinoma are arbitrarily formed on the same plan, the name sarcoma being given to tumors composed of tissues of connective-tissue origin resembling those normally found in the fœtus but not in the adult, and carcinoma to tumors made by a wholly unnatural growth of epithelial cells.

Tumors may be divided into two main classes, according to their origin from the connective tissues or from the epithelium.

There is a fundamental difference between the tissues of the mesoblastic layer of the fœtus, from which arise the bones, muscles, connective tissue, blood-vessels, etc., and the epiblastic and hypoblastic layers, which produce the epithelial tissue—skin, mucous membranes, and glandular structures. As no cell originates spontaneously, every cell must be descended from a previous cell, and it has been proved that every cell inherits the characteristics of its parent cell; in other words, "like begets like." On account of this rule a cell belonging to the mesoblastic layer, whether it is in the bone, muscle, or connective tissue, or is one of the endothelial cells lining the vessels or serous cavities, can produce only a connective-tissue cell, never an epithelial cell; and, conversely, a cell belonging to the other two layers can produce only epithelium. This rule applies to the origin of tumors as well as to the growth of normal tissues. Epithelial tumors such as adenoma and carcinoma can originate only from tissues or organs which contain epithelial cells. Bony, fatty, and other tumors composed of tissues of mesoblastic origin, and sarcoma which resembles the connective tissues of the fœtus in structure, can grow only from tissues of like origin.

It has been shown that there is a definite connection between the structure of tumors and their clinical course. It may be said in a general way that the more nearly the structure of the tumor approaches some normal

adult tissue or the structure of a normal organ the more benign will the growth be; and that, on the other hand, the farther it departs from these types the more malignant will be its clinical character.

Etiology.—The two most generally accepted theories of the origin of tumors are that of Cohnheim, known as the theory of fœtal inclusion, and Volkmann's suggestion of traumatic origin.

Fœtal Inclusion Theory.—Fœtal tissues are remarkable for their power of growth rather than for their functional activity. Cohnheim imagined that small fragments of embryonic tissue might be displaced during fœtal development and might lie dormant in their unnatural situation until some injury or unknown influence stimulated them to grow. The supposition implies that many thousands of these fragments of fœtal tissue, consisting of single cells or groups of cells, exist in all parts of the body, ready to develop.

Traumatic Theory.—Volkmann's theory supposes that the normal cells may be changed by some traumatic influence and begin to grow in an unnatural way, thus producing a neoplasm. The tumors of the connective-tissue group are apt to follow a single injury, whereas the epithelial tumors are more likely to follow chronic irritation of the epithelium by mechanical, chemical, or other agents. In the first case, a contusion or other injury of the soft parts of a limb occurs, blood is extravasated, and changes of repair begin. When the repair has been finished, all these changes should become retrogressive, the cells should return to their normal condition of slow growth and carry on their functions. But sometimes their reaction to the injury appears excessive, and they grow out of proportion to the necessity of the case, and more new tissue is formed than can fully organize, so that it persists in the fœtal character, and a malignant connective-tissue growth—a sarcoma—is the result.

In the second case, continued irritation of an epithelial cell tends to make it multiply, and instead of producing its normal secretion it turns all its energies towards reproduction. It then has a tendency to penetrate the connective-tissue layer or basement membrane on which it should normally lie, and thus malignant epithelial tumors originate. The appearance of a tumor as the immediate result of a blow is not very common, an osteosarcoma following an injury to a bone (more frequently a contusion than a fracture) being probably the most frequent example, and the production of the benign tumors, such as fibroma or lipoma, by such causes is very rare. Carcinoma and epithelioma, however, are seen almost daily as the result of continuous irritation. Epithelioma often originates in the lip where a short hot pipe is held in smoking, or about the edges of an old ulcer of the leg. Epithelial growths are frequently found in situations liable to irritation and injury, the majority of the epitheliomata of the mucous membranes being situated on the lips, on the tongue, in the larynx, the pylorus, the ileo-cæcal valve, or the rectum. The testicle is peculiarly liable to malignant disease when retained in the inguinal canal.

Traumatic Epithelial Cyst.—A peculiar form of tumor directly produced by injuries is the traumatic epithelial cyst (Garré, Reverdin). It is supposed that a small portion of the external epidermis is carried downward

by the force of a blow by some pointed object, entirely detached from the skin, and lodged in the deeper parts, and that this fragment of epithelial tissue tends to roll up at once, with the epithelial cells inside and the corium outside, the latter forming a capsule by the uniting of its edges. The epithelial cells then grow in the centre and distend this closed capsule, producing the typical cyst. Usually the epithelial cells die and degenerate in the centre, making a cheesy mass, the tumor resembling a sebaceous cyst, but occasionally they remain viable, and a solid epithelial growth may result, as has been reported in one case on the forehead. These cysts are relatively frequent on the palmar surface of the hand. As there are no sebaceous glands on the palms, and as dermoid cysts do not form here, these two varieties of tumors are easily excluded in the diagnosis, and a clear history of antecedent traumatism can often be obtained for the epithelial cysts.

Parasitic Theory.—Recently an attempt has been made to revive the so-called germ theory, referring all tumors to a parasitic origin. The parasite now favored, however, is not a bacterium, but an animal parasite known as a *coccidium*. The majority of pathologists believe that the grounds on which this theory is based are insufficient, and that the appearances in the cancer-cells which are supposed to be the parasites, their products, or their eggs, are certain alterations of the cells or their nuclei.

Trophic Influences.—It has long been known that certain vaso-motor or other reflex influences control the growth of tumors, multiple fatty tumors of the skin or of the subcutaneous connective tissue being very common in certain forms of central nervous disorders, but the bearing of the latter upon the etiology of tumors is not yet understood.

Age.—Sarcoma and nearly all the connective-tissue group are common in both young and old, but the malignant epithelial tumors are unusual before middle life. Thiersch has pointed out that in old age certain changes take place in the tissues, with a tendency to overgrowth of the epithelium and atrophy of the connective tissue, especially in such organs as the lip and the tongue (Woodhead), the epithelial cells also tending to penetrate the connective tissue. Thiersch supposes that there is a loss of balance of growth between the two tissues, and that their relations therefore become irregular; but it is probable that the changes which occur in old age are only predisposing causes, and that some irritation is needed also in order to produce the growth. Aside from the necessarily congenital tumors (dermoids) and angioma, neoplasms are rarely seen in the new-born. Children are less likely to have malignant tumors than adults, but even the malignant epithelial tumors are occasionally found in very early life.

Sex.—The influence of sex is of less importance, except in the sexual organs: the breast in the male, for instance, is an atrophied organ, and malignant tumors in it are rare, whereas in the female it is one of the parts most commonly affected. There are, however, some curious exceptions. Epithelioma of the lip, for instance, is rare in women. When it does occur in women it is found in the large majority of cases on the upper lip, whereas in men, in whom epithelioma of the lip is very common, the lower lip is almost invariably the one attacked. Carcinoma of the tongue is also said to be rare in women, but the statistics need revision upon this point.

Race and Country.—Some races seem to be more predisposed to certain tumors than others, keloid and uterine fibromyoma being very common in the negroes and fibrolipoma in certain East Indian races. Attempts have been made to prove that cancer is indigenous to certain districts in various countries, but without much success, although it cannot be denied that the inhabitants of a few valleys in France and certain districts in England and Germany appear to be peculiarly liable to the disease.

Contagion of Cancer.—There is a theory that malignant tumors are contagious, and a few isolated facts of this kind are on record, but they are to be taken with a certain amount of reserve. The coincidence of epithelioma of the penis and of the uterus in man and wife in rare cases has been quoted in proof of this theory, but the very great frequency of epithelioma of the uterus and the rarity of the same disease in the penis argues against their origin by direct infection. There are many cases on record in which a cancerous ulcer has apparently infected the part in contact with it, for example, from the lower to the upper lip, from the gum to the cheek, from the breast to the skin of the chest; but in such instances we are dealing with an inoculation of an individual already the subject of the disease. This theory of infection and the fact that in certain districts carcinoma appears to be more frequent than in others are the two corner-stones of the foundation of the theory of the parasitic origin of cancer, for the disease would probably be contagious if it were parasitic. But the parasitic theory is far from demonstration.

DERMOID, BRANCHIAL, AND THYROGLOSSAL TUMORS.

DERMOID TUMORS.

Origin.—The dermoid tumors afford a good illustration in gross of Cohnheim's theory. During the development of the fœtus various parts are formed by projections or folds growing inward from the external epithelial covering, and normally the pedicles of these infoldings should disappear by atrophy of the epithelial cells, leaving the mass of buried epithelial cells entirely separated from the superficial layer, ready to form the special organ. The groove or dimple on the surface where the infolding began then fills up level with the surrounding parts. Occasionally this atrophy is incomplete, and groups of epithelial cells may persist in the connective tissue in the track of the pedicle between the organ and the epithelial layer. If any injury or irritation causes the cells so included to grow, the connective tissue about them forms a capsule, and solid or cystic tumors result. In the cysts the cells die in the centre and produce a cheesy mass, for only those on the periphery next the capsule can obtain sufficient nourishment to live.

Situation.—These cysts may be found wherever natural clefts occur in the fœtus, but they are most common about the face, especially at the external angle of the orbit. (Fig. 41.) They are rarely found in the median line, but are occasionally seen about the anterior fontanelle or along the lambdoid suture. In the latter situation they represent the infolding of the surface of the ovum and fœtus to make the deep fissures dividing the brain into the different lobes, and hence dermoid cysts are also found in the brain.

In the occipital region an entire series of cases of these cysts has been collected, showing their mode of development, beginning with cysts in the occipital lobe of the brain, some of which are attached to the occipital bone by a pedicle. Next there are dermoid cysts between the dura and the skull, and others in the bone. Finally, there are dermoid cysts under the skin, with pedicles attached to the bone, making the series complete. Dermoid cysts are also found elsewhere on the head, and we have removed one which lay over the masto-squamous suture. They are very rare on the skin of the trunk, but they may occur in the median line. They are rare on the external genitals, but frequently originate from the ovaries, and may form large tumors. Those which have been reported in the upper part of the abdominal cavity, without any connection by a pedicle to the pelvis, are probably instances of cysts which originated in the ovary but have broken their pedicles and become transplanted elsewhere. For a description of the ovarian dermoids we refer to the section on the ovary. Very rarely dermoids have developed in connection with the folding in of the skin at the umbilicus.

Fig. 41.

Dermoid cyst at external angle of orbit.

Structure.—The term dermoid in connection with these cysts should be understood in its fullest significance, for all the various structures produced by the skin are to be found in the sac. The most common is the hair which grows on the inner side of the cyst-wall, occurring either in tufts or lining the entire cyst, the hair being long or short. Sometimes the lining skin is affected with alopecia, the hair being found loose in the sac, while the epithelial lining is perfectly bald. Hair, teeth, and finger-nails have been found in these structures, and bony plates are not infrequent in the deeper layers, owing to ossification of the corium. A rudimentary mamma has even been observed, which is not surprising, for the normal mamma is considered simply an altered sebaceous gland. The various tissues or organs which the dermoid cysts contain may be attacked by hypertrophy or by the development of neoplasms, like the similar external tissues. Thus, sarcoma, papilloma, or epithelioma may develop, and the bony deposits represent osteoma. While hair is a common occurrence in all dermoid cysts, the more complicated structures just mentioned are to be found only in connection with those tumors which originate from the pelvic organs.

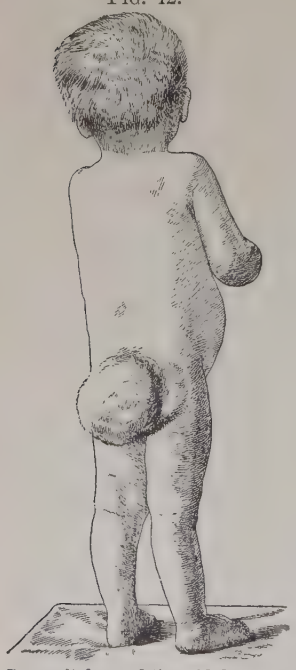
There is usually a depression in the bone under dermoid cysts situated over the *skull*, caused not so much by the direct mechanical pressure as by the accompanying failure of development of the bone at this point. In some instances there is a complete opening in the bone, the pericranium and the dura mater being in contact, which may be an awkward complication during an operation. Dermoid cysts of the head are seldom large, although they may attain the size of a hen's egg, they have very little tendency to become

inflamed, and the skin over them is generally well nourished and seldom ulcerates.

Treatment.—A dermoid cyst can be removed only by operation, and the sac must be completely extirpated or it will reproduce the tumor. The superficial tumors are usually small. Their removal is generally undertaken for cosmetic purposes only, and the operation is simple, involving merely an incision of the skin, turning back the flaps, and shelling out the tumor. In the case of dermoids on the edge of the orbit, however, a prolongation of the sac will sometimes be found running down well into the orbit, although it will seldom be found attached there, and can generally be shelled out by blunt dissection without injury to the contents of that cavity. Occasionally the intra-orbital part is connected with the extra-orbital part by a very narrow pedicle, and therefore it is important to look carefully for such a process in attempting the removal of the cyst, as the part within the orbit will reproduce the tumor if overlooked. The treatment of the dermoids originating in the ovary will be discussed under the head of pelvic and abdominal tumors.

Thyroid Dermoids.—The solid dermoid tumors are called *thyroid dermoids.* They occur only in the pharynx or in the neighborhood of the coccyx. In the latter situation they arise from remains of the depression which forms the anus and the anal part of the gut. The solid tumors are made up of epithelial cells in a fibrous-tissue stroma, which divides them into lobes resembling somewhat the structure of a thyroid gland, whence their name. (Fig. 42.) They sometimes attain such a size in the coccygeal region that the child seems an appendage of the immense tumor, on which it sits as on a cushion. In other cases the tumor grows within the pelvis. The pharyngeal tumors project into the mouth or even externally, and are very rare. The removal of the thyroid dermoids from the region of the rectum is, as a rule, a very serious matter, for the tumors are large and well supplied with blood, and the bowel and bladder are often adherent and exposed to injury. It should be noted that not all dermoid tumors in the region of the anus are of the solid variety, dermoid cysts also being found in the neighborhood of the coccygeal dimple.

FIG. 42.



Congenital sacral thyroid dermoid.

BRANCHIAL CYSTS.

In the development of the face and neck, the lower jaw, larynx, thyroid gland, and tongue are formed from projections which grow forward on each side of the neck from the main mass of fœtal matter in the neighborhood of the spinal axis. These projections are separated by grooves known as the branchial clefts, but the clefts are not complete, for both the ectoderm and

the entoderm (skin and mucous membrane) are continuous from one projection to the next, the mesoderm (connective tissue) being wanting at the so-called cleft. The inner and outer layers, however, are often defective at the bottom of the grooves, and small openings may exist in the clefts. When the projections from both sides meet in the median line the clefts or grooves between adjoining projections fill up to the level of the parts on each side of them, the two membranes (entoderm and ectoderm) being separated by a growth of mesoderm between them. Occasionally, however, this filling up is incomplete, and a deep sinus may persist between two neighboring projections, passing from the outer surface of the skin directly to the inner surface of the pharynx and the adjacent parts. The outer part of such a passage is lined with epithelium corresponding to the skin, and the inner part with that corresponding to the mucous membrane. There may be a thin membranous septum between them. The external auditory meatus and the Eustachian tube are naturally formed in this manner, and the membrana tympani represents the septum between the two parts. If on account of irregular development both ends of one of these abnormal sinuses be closed by the parts growing over them, a cavity will be left in the middle, which is lined by epithelium and forms a cyst, sometimes attaining a large size. (Fig. 43.)

Fig. 43.

Congenital cystic tumor of the neck.

The character of the epithelial lining will depend upon the part of the sinus which has originated the cyst, and if it be near the skin the cyst will have the characters of a *dermoid cyst*, while if it be near the mucous membrane the epithelium will be mucous epithelium and will form a typical *branchial cyst*. The wall of a branchial cyst is made up of connective tissue with a lining of mucous membrane epithelium, which is usually of the cylindrical variety, but may be ciliated when it originates from the same epithelium as the apex of the pharynx. The contents will be a clear or milky mucoid fluid, secreted by the mucous lining. If the cyst is exactly in the centre of the cleft, one side of the cyst may be of the dermoid and the other of the mucous variety, and the contents show a mixture of the two. We have removed a cyst situated high up on the sternum near the episternal notch which showed a very abrupt transition from one epithelium to the other at a certain point of the wall.

The important parts of the neck, formed by the branchial projections, are as follows: the first pair form the inferior maxilla and lower lip; the second pair form the styloid process, the stylo-hyoid ligaments, and the lesser cornua of the hyoid bone; and the third pair form the rest of the hyoid bone. The anatomy of the third and fourth pair is not thoroughly understood, but the thyroid gland and the thymus originate from these structures,

the third forming the two lateral lobes of the thyroid gland. Branchial cysts may therefore be found anywhere in these regions.

Treatment.—When branchial cysts are large they demand removal by operation, and the dissection may be very difficult, on account of their close relations to the vessels, nerves, and deeper parts of the neck. In some cases a cure has been obtained by aspiration and injection.

THYROGLOSSAL TUMORS.

The central lobe of the thyroid is formed by a special turning in of the mucous membrane at the root of the tongue, which forms a process of epithelial cells running forward through the body of the hyoid bone to the centre of the thyroid gland. This process is usually spoken of as a canal, but for nearly the whole of its length it is a solid cord of epithelial cells without any lumen, running forward and downward from the root of the tongue at the foramen cæcum and terminating in the pyramidal lobe. Tumors frequently develop from this band of epithelial tissue, and are known as tumors of the thyroglossal process or duct (Bochdalek). In the course of development the hyoid bone becomes solid even where the epithelial tissue crosses its centre, the epithelium disappearing at this point. By that time, however, the distal part of the process towards the thyroid gland should be entirely absorbed or converted into thyroid tissue. In some cases small masses of epithelium remain in the track of the cord, but separated from the gland on one side and from the pharynx on the other. These may grow and form solid tumors like the thyroid in structure, or cysts closely resembling the dermoid cysts. They can be recognized by their situation in the course of the former cord, although occasionally they may lie somewhat to one side, as diverticula are found extending from the epithelial mass on either side. These tumors sometimes reach the size of a goose-egg (Fig. 44), and may cause a little difficulty in swallowing and some deformity, or they may suppurate, and when incised they leave a permanent sinus, discharging a mucoid fluid. Solid tumors and cysts may also develop in the substance of the hyoid bone from that part of the epithelial cord which passes through it, or between the hyoid bone and the tongue. If these cysts should project in the floor of the mouth, coming forward between the tongue and the lower jaw, they are very liable to be mistaken for ranula, but should be easily recognized by their contents, which are very like the sebaceous matter of the dermoid cysts. The solid tumors at the base of the tongue may be mistaken for sarcomata.

Fig. 44.

Thyroglossal cyst.

Congenital cysts, which are usually of the branchial type, occasionally dermoids, and occasionally solid masses of thyroid or thymus tissue, may, therefore, be found anywhere in the clefts between these fœtal processes,

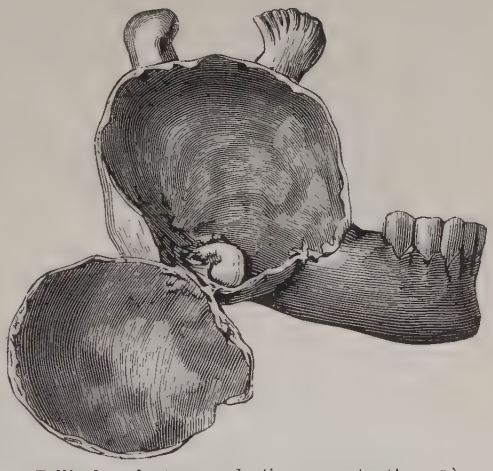
but the branchial and dermoid cysts appear to be very rare in the median line, being usually situated laterally on the anterior surface of the neck. Many of the cysts in the median line of the thorax are to be considered as dermoid or branchial cysts which have developed in the neck and then wandered downward by gravity, as is not uncommon in fluid tumors, so that they may appear in front of the sternum, and they must not be confused with dermoid cysts originating in this situation. The tumors originating from the thyroglossal tract may be reached externally, or through the floor of the mouth in front of the tongue, but the external operation should be preferred, as it will be more aseptic.

ODONTOMATA.

An odontome is a tumor developing from some part of the tooth-germ. A tooth-germ may be displaced and may grow abnormally, just as fragments of displaced epithelial tissue form dermoid cysts. We therefore consider the odontomes next to the congenital cysts, although they originate at a later period.

Classification.—Sutton classifies the odontomes according to the part of the tooth-germ from which they arise. 1. From the **enamel organ** come certain **epithelial cystic tumors,** usually multilocular, which may attain a very large size and involve the entire jaw, although individual cysts are generally small. The gross appearances of these tumors resemble those of giant-celled sarcomata of the bone. 2. **Follicular odontomata.** From the tooth-follicle originates a tumor containing as a centre a more or less irregularly developed tooth, which may be very small. (Fig. 45.) A large amount of fluid may surround the tooth in the distended follicle and form a cyst of considerable size, called a **dentigerous cyst.** If the sac of this cyst thickens and the fluid disappears, a solid tumor is formed, in which the small and malformed tooth may be overlooked. This variety is known as a **fibrous odontome**; but the sac may also calcify or even ossify. Sometimes several tooth-follicles are concerned in this process, and a large number of irregular teeth are found, to the number of three or four hundred in one tumor, which may form large irregularly shaped masses of fibrous material, partly calcified or ossified, and containing cystic cavities. 3. Tumors arising from the papillæ are called **radicular tumors.** They contain only cementum and dentine, and are rare tumors, found attached to the roots of the teeth. 4. **Composite odontomata.** (Fig. 46.) Sometimes all parts of the tooth-germ are concerned in

Fig. 45.

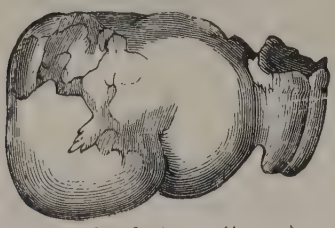


Follicular odontome or dentigerous cyst. (Agnew.)

the tumor formation, making masses of enamel, dentine, and cementine, or it may be composed mainly of one substance. (Fig. 47.)

Clinical Appearance.—Odontomata are generally seen soon after puberty or in early adult life. They form hard tumors, often of considerable

Fig. 46.



Composite odontome. (Agnew.)

Fig. 47.

Solid enamel odontome. (Agnew.)

size, usually about the lower jaw, more rarely in the upper jaw or the antrum, covered with normal mucous membrane, generally painless, of very slow growth, and objectionable only because of the deformity which they occasion. They may become infected and give rise to symptoms resembling necrosis. Their existence should be thought of in connection with any tumor about the alveolar border, or in any case of necrosis which presents unusual clinical characteristics. The diagnosis can generally be made by a study of the teeth, observing their irregular formation, or the congenital absence of one or more of them. A skiagraph taken by the X ray may show the tooth in the centre of the tumor. In any doubtful case the supposed sarcoma should be explored by incision before sacrificing the jaw. If the tumor contains one of these badly formed teeth in its centre, it is certain to be an odontome and not malignant.

Treatment.—Odontomes should be removed by exposing them and dissecting out every part of the lining of the sac, chiselling away enough bone for this purpose.

FIBROMA.

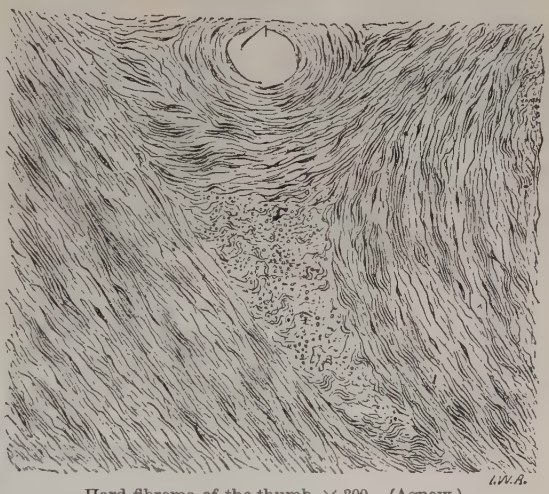
A fibroma is a tumor composed of any of the different types of fibrous tissue.

Structure.—Some fibromata are formed of a hard, dense, ligamentous tissue, with fibres closely woven in different directions, but often arranged concentrically around the blood-vessels. (Fig. 48.) Some are of looser and somewhat elastic structure, and still others have a wide-meshed areolar tissue often filled with serum, which gives them the appearance of œdematous tissue. Besides the pure fibromata, fibrous tissue is often found as a part of other tumors, associated with fat in fibrolipomata, or with muscular tissue in uterine fibromyomata, or forming the stroma of malignant tumors. The boundary line between fibroma and fibrosarcoma is sometimes very ill defined, sarcoma being distinguished by the presence of a certain quantity of actively growing cells instead of the quiescent fibres, by the shorter and broader nuclei, and by the incomplete capsule. Hard fibromata are usually supplied with very small blood-vessels and are well encapsulated, and they

grow slowly. The softer variety is sometimes very vascular and sometimes deficient in blood-supply, sloughing readily in the latter case. The lymphatic spaces in the soft tumors are sometimes so much distended by serum as to resemble œdematous tissue, or even to form true cysts.

Occurrence.—As fibrous tissue is found throughout the body, fibromata occur in almost any situation. The hard fibromata may develop in soft glandular organs, and soft fibromata may occur in connection with tendons, although dense, hard fibromata often originate from the ligamentous structures in the fingers or about the joints, and from the fibrous sheaths of the nerves. Fibroma of the tendons is rare. The soft variety is usually found in the subcutaneous connective tissue, and also grows from the corium of the skin. Fibromata may develop in the periosteum, and growths of this character are most frequently found attached to the jaws, the palate, or the base of the skull. In the latter situation they form the nasopharyngeal polypi. (See chapter on the Nose.) A peculiar form of fibrous tumor known as a *desmoid* grows in the muscular and tendinous parts of the abdominal wall. These tumors are not very well encapsulated, and resemble sarcoma, having a tendency to return after removal.

FIG. 48.



Hard fibroma of the thumb, × 300. (Agnew.)

Clinical Appearances.—A fibroma of the hard variety is a smooth or nodular painless tumor, freely movable under the skin or in the affected organ, although sometimes adherent at its point of origin, and varying in size from a pea to a horse-chestnut. The soft fibroma is jelly-like or semi-fluctuating, often pedunculated, covered by normal skin or mucous membrane, painless, and may attain a much larger size.

History.—These tumors may cause ulceration of the skin by pressure. If pedunculated they may slough if the pedicle is twisted, and if infected they become inflamed. They are very liable to cystic degeneration. Calcification and ossification also occur. They do not return if thoroughly removed, and with extremely rare exceptions they do not form metastatic tumors.

Varieties.—A **keloid** is a fibrous tumor of the skin which develops from a scar. (Fig. 49.) Keloids of spontaneous growth do not exist, for those of unknown origin probably grow from a minute scar, such as that left by an acne pustule. The distinction between *keloids* and *hypertrophied scars* is a clinical one, the main difference between them being that a hypertrophied

scar becomes stationary after a time and may grow smaller and flatter, and that the scar is not usually so bright red as the keloid is apt to be. The keloid forms a densely hard, flat tumor in the substance of the skin, sometimes with a straight edge, but more frequently with claw-like projections reaching into the surrounding skin, whence its name. It may be white, but is usually pinkish in hue. It tends to spread slowly but steadily on all sides. Keloids are occasionally multiple, and form large warty tumors in some cases instead of flat patches. Certain individuals seem to have a predisposition to keloid, particularly in the negro race. Keloids appear on all parts of the body, but most frequently upon the front of the chest.

Fig. 49.

Spontaneous keloid. (Ohmann-Dumesnil.)

Fibroma-molluscum is a curious tumor of the skin, consisting of a fibrous tumor starting in the corium, projecting through the epithelial layers, and forming a pedunculated growth. It is quite soft, and when pressure is made upon it in the early stages, when it does not project much beyond the level of the surrounding skin, there appears to be a gap in the skin at that point, through which the soft tissue projects. The tumors continue to grow until they reach the size of a small bean, and then the opening in the corium through which they have appeared to come grows smaller, cutting off their blood-supply, and the interior of the tumor softens and disappears, leaving only a bag of the upper layers of the skin at the point where the tumor originated. Finally, this shrivels up and disappears, so that in this

instance there is a spontaneous disappearance of a tumor. In many cases, however, these tumors are permanent and may attain a large size.

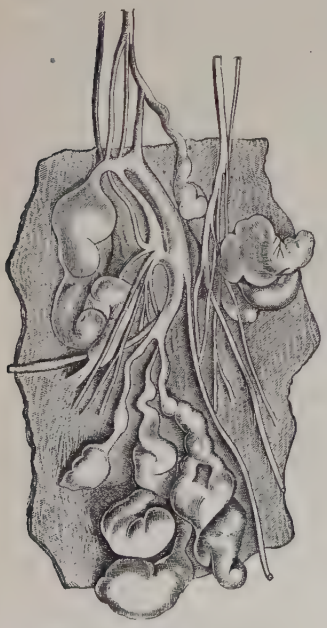
The so-called **fibromata of the uterus** are composed rather of unstriped muscular fibres than of fibrous tissue, and will be considered under the head of myoma. The majority of **fibromata of the mamma** are really fibro-adenomata, and will be described with that organ.

Fig. 50.

Central fibroma of nerve-trunk. (Agnew.)

Fibroma of the sheaths of the nerves is rare, but is found in two varieties. In the first a single tumor forms in the sheath of the nerve, involving the entire trunk or growing upon one side of it. Sometimes the nerve-fibres are spread over the outside of the tumor (Fig. 50), and by splitting the sheath of the nerve the tumor can be enucleated from the centre of the fibres without injury. In other cases the two are so intimately connected that it is impossible to separate them, and a part of the nerve must be removed with the tumor. The fibromata of nerves are rather small, and usually not of much clinical importance, unless they excite pain by their pressure on the nerve. Sometimes they appear as small nodules in the skin, and their connection with the nerve can be determined only by the pain on pressure, or by the anatomical proof that the nerve enters them. They may be multiple, and have been considered by some as tumors of the skin only, and called "painful subcutaneous tubercles."

Fig. 51.



Plexiform fibroma of nerves. (Agnew.)

The second variety of fibroma of nerves is the curious and rather rare condition known as **congenital elephantiasis of the nerves, or plexiform neuroma.** (Fig. 51.) In this disease the main trunk of the nerve is very much enlarged by an hypertrophy of the subdivisions of the fibrous sheath (the endoneurium), while the perineurium remains intact and prevents the growth from extending to other structures. The true nerve-fibres do not undergo any enlargement or increase in their numbers (although the early observers claimed that this was the case), and the growth is entirely in the fibrous structures, so that it does not interfere in any way with the transmission of impulses through the nerve or with its function. The thickening and enlargement extend downward along the nerve even to its filaments in the skin. The nerves are lengthened as well as thickened, so that they form long serpent-like cords in their course instead of running straight, and in some places they form tumors of considerable size. The involvement of the terminal filaments in the skin gives the

impression of hypertrophy or elephantiasis of the skin. (Fig. 52.) The disease is essentially a new growth of the nerve-sheath, and it may finally involve all the cerebro-spinal nerves, although it is very slow in its extension, and may remain limited to the nerves of one limb or even to one group. The change never invades the central nervous system, but is arrested at the foramina of exit of the nerves, and the optic and auditory nerves are never affected. The disease is generally supposed to be of congenital origin, although it is seldom recognized during infancy. It produces neither paralysis nor pain, and extends insidiously until large tumors may be produced. The latter are apt to become sarcomatous in structure and recur when removed. No treatment is possible in this disease, although some recent writers have advocated thorough extirpation when the disease is limited to one nerve or one group of nerves.

Fig. 52.

Plexiform fibroma of peroneal nerve. (Hulke.)

Treatment.—The removal of fibromata is a simple operation, as they are usually well encapsulated. The capsule, however, should be removed, as the growth appears, in some cases at least, to come from the capsule. All prolongations of the tumor in one direction or another are to be removed also, or the tumor may be reproduced. The treatment of *keloid* is very difficult and unsatisfactory. Small keloids may be excised and the wound sutured, but they are apt to return even when perfect aseptic healing of the wound is obtained. Of other measures, that most generally in use is multiple scarification with cross-hatching lines. With a very sharp knife fine lines are carried across the tumor, cutting completely through its epithelial surface, some twelve to twenty to the inch, reaching to the healthy tissue at the edges of the growth, and crossed by another set at right angles to the first. If the knife be very sharp, this treatment may be rapidly executed, and is not very painful, but local anæsthesia can easily be produced by cocaine injections or by the ethyl chloride or other cold sprays. Attempts to remove the keloid by electrolysis have not been very successful.

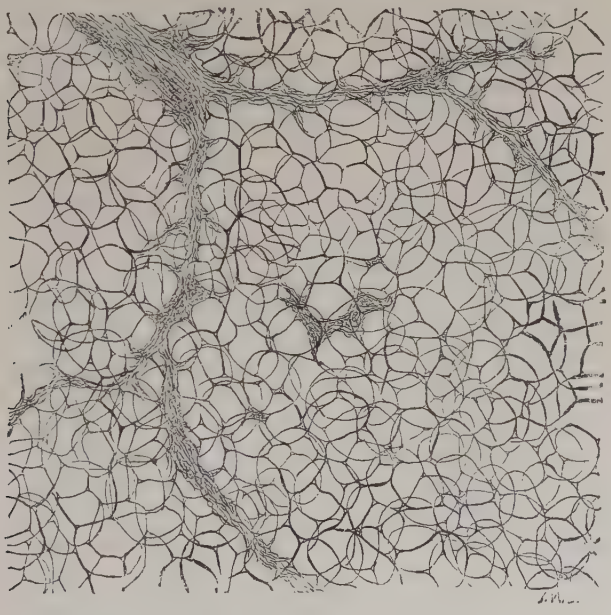
LIPOMA.

A lipoma is a tumor formed of fatty tissue, and, as fat is of almost universal distribution in the body, lipomata are to be found everywhere. The microscopic structure of the tumor consists of a loose fibrous stroma, with

particles of fat included in it, very like the subcutaneous tissue (Fig. 53), but in some cases the stroma is much more abundant and the amount of fat much less. When the two are equal in amount the tumor should be called a *fibrolipoma*. The fibrous tissue also forms a capsule, but the meshes of the stroma often pass through the capsule, and are continuous with the stroma of the normal subcutaneous tissue, extending up into the corium. The capsule is sometimes wanting, and a diffuse lipomatous growth results without any definite limit.

Occurrence.—The most common situation of lipomata is in the subcutaneous tissue, but they are also found deep down among the muscles of the body or under the mucous membrane of the intestines. Lipomata are even found where fatty tissue does not exist normally (in the kidney and brain, for example), and their existence in such cases can be explained only

Fig. 53.



Lipoma from the thigh, × 40. (Agnew.)

by the assumption that some displacement of the fœtal tissues has occurred. Subcutaneous lipomata are most common on the neck, the back, the upper parts of the extremities, and the abdomen. They are not usual on the head, and are rare on the *feet* and *hands*, only fifteen or twenty cases of the latter being on record. When they occur in the palm of the hand or on the plantar surface of the foot they tend to grow deeply between the bones and to project upon the opposite side, forcing the bones apart, and this peculiarity enables one to make the diagnosis between them and certain forms of chronic disease of the tendon sheaths, which produce tumors of about the same size and consistency. Lipoma also occurs within the *tendon sheaths* and in the *joints*, or even in the *bursæ*, and may simulate tuberculosis of these parts. Lipomata are quite common in the layer of fat which lies just without the

inguinal and femoral rings and in the omentum and mesentery. Fatty tumors also occur between the mamma and the chest. A curious form of lipoma—the so-called *parosteal lipoma*—is found on the bone under the periosteum, and is supposed to be always of congenital origin, for it is usual to find a depression in the bone due to its pressure. A few cases of this kind have been reported, some of them on the long bones and some on the bones of the skull under the pericranium; but the diagnosis of the former is not likely to be established before operation, and the latter are liable to be mistaken for dermoid cysts.

Clinical Appearances.—A subcutaneous fatty tumor is usually well encapsulated and freely movable, although slightly adherent to the skin, growing slowly, but sometimes attaining a very large size. These tumors vary in density very greatly, according to the amount of fibrous tissue stroma and the state of tension of the capsule, and a deceptive wave, like the fluctuation of a cyst, may sometimes be obtained. When the tumor is pinched up between the fingers the skin over it dimples from the attachment between the two made by the fibrous bands of the stroma. If the lipoma lies under the superficial fascia, however, this pulling on the fibres of the skin does not take place. On the other hand, a lipoma may develop in the corium itself, in which case the epithelial part of the skin is stretched tightly over it and cannot be made to dimple, and the tumor closely resembles a sebaceous cyst, the resemblance being increased if the contents be soft and the capsule tolerably tense, so that a feeling of fluctuation can be obtained. While lipomata are, as a rule, rather flat tumors, or, at the most, globular, they may become pedunculated, and this, in our experience, is most common in tumors situated in some of the flexor parts of the body, such as the axilla, the folds of the groin or the buttocks, and the popliteal space. It seems probable that the tumor is forced out through the superficial fascia and made to distend the movable skin in these localities by the pressure of the parts in flexion. These pedunculated lipomata sometimes attain a large size and have a very long pedicle. Pedunculated lipomata are very liable to twisting of the pedicle or to some injury which forms a hæmatoma, and may result in sloughing. Multiple subcutaneous lipomata are sometimes found scattered all over the body in great numbers, and some constitutional nervous disease is so often associated with their appearance that they are supposed to be due to some unknown trophic influence.

History.—Lipoma grows very slowly, and often remains stationary for years. Cysts containing oil are found in these tumors in rare cases, and calcification or myxomatous degeneration of the stroma is occasionally seen. They are liable to inflammation, like ordinary fat, and they frequently become infected with tuberculosis when in the neighborhood of tuberculous joints, like the fatty tissue which lies just outside the capsule. The only effects produced by these tumors are those due to their bulk or the deformity they occasion.

Treatment.—If operation is considered desirable, the tumor should be removed, together with the capsule. In some cases a pedicle can be traced from the superficial tumor down through the deep fascia to another mass between the muscles. In one case a deep-seated thoracic lipoma had a pedicle which

passed between the ribs to a similar tumor in the chest. These prolongations should be carefully followed out and removed, or the tumor will grow again. Removal by operation is the only possible treatment.

MYXOMA.

Myxoma is a tumor formed of a tissue like the so-called Wharton's jelly of the umbilical cord, which is not found in adult life except in the vitreous humor and in occasional degenerations of fat or bone. Its foundation consists of a transparent mucin-holding substance in which ramify stellate or fusiform cells with small round nuclei, the branches of the cells often communicating and forming a delicate reticulum. (Fig. 54.) Tumors of

FIG. 54.

Myxoma from the peritoneum, × 300. (Agnew.)

this kind are found in the neighborhood of the umbilicus, in the subcutaneous tissue, the brain, and other parts of the body. Myxoma is said to stand midway between the benign and the malignant tumors. Myxomatous tissue is often found as a partial ingredient of the sarcomata, but the pure myxoma is considered benign, and should be associated with the lipomata, for the fatty structures of adult life originate from myxomatous tissue in the fœtus. These tumors are of little clinical significance, on account of their rarity, but should be removed for fear of sarcomatous degeneration.

OSTEOMA.

An osteoma is a tumor composed of bony tissue. Bony tumors attached to the external surface of bones are known as exostoses ; the term enostosis has sometimes been given to bony tumors projecting into the skull, growing from its inner layer, but it should be reserved for bony tumors growing centrally in a bone.

Structure.—The structure is simply that of either cancellous or compact bone, without any regular arrangement, except that in globular tumors the fibres are placed in concentric layers, because they grow from an external layer of cartilage ossifying behind it. (Fig. 55.) Exostoses may be met with on the face, attached especially to the jaws or frontal bones, and similar tumors are found in other parts of the skeleton, particularly in the flat bones. Those on the skull are sometimes densely hard, and no Haversian canals can be seen in them, whence they are called ivory or eburnated exostoses. Another form of osteoma is that which grows from the epiphyseal ends of the long bones, produced by the ossification of tumors originally cartilaginous. Ossification is found extending from the bone down into the attachments of ligaments and muscles, forming irregular exostoses more or less pointed at the free end, where they terminate in the muscles or tendons. These masses are not properly osteomata.

Occurrence.—The various bones differ in their liability to osteoma, the phalanges, the femur, the tibia, the humerus, the vertebræ, and the flat bones,

Fig. 55.

Osteoma of femur, × 200. (Agnew.)

such as the scapula, being liable in the order given, but there is no bone that is entirely free from it. Osteoma may grow from the phalanges under the nails, lifting the latter. Although osteoma usually springs from bone, or at least from periosteal tissue, it also occurs rarely as an independent neoplasm in such organs as the breast, the testicle, and the brain, from ossification of cartilaginous tumors. Osteomata are multiple in one-tenth of the cases, and this variety seems to be hereditary in some families, in which, curiously enough, they often affect only the males, the female side escaping.

Clinical Appearance.—Osteomata form hard, rounded tumors, often more or less pedunculated, frequently lobulated on the surface. The skin

is freely movable over them, and a bursa is often developed between them and the surrounding soft parts. They vary in size, the pure osteomata, and especially the eburnated variety, seldom being large, but in some cases, when combined with cartilage, they may reach the size of a man's head. They are fixed on the bones, and are free from pain and tenderness.

History.—These tumors enlarge very slowly, often remain stationary for long periods, and seldom cause any symptoms unless they grow in a closed cavity, like the antrum of Highmore, when they may cause pain from pressure and interfere with the functions of the neighboring nerves. Osteoma is liable to inflammation and necrosis, but never undergoes malignant degeneration.

Treatment.—The only treatment for osteomata is removal by operation, but in many cases they may be left untouched. Operation may be rendered necessary by the mechanical interference of the tumor with the motions of a limb, its large size, or the deformity it occasions. It is also necessary to remove osteomata developing in the sinuses of the facial bones as soon as they distend the latter. The ordinary exostosis is easily removed with the chisel, but the base should be thoroughly gouged out, to prevent recurrence from the cartilaginous matrix often found beneath it. The ivory exostoses will generally require the use of a saw, on account of their great hardness. To remove osteomata from any of the sinuses the latter must be opened, and, if the tumor springs from the deeper wall of the frontal sinus, care will be necessary to avoid injury to the brain, as it not infrequently extends deeply into the cavity of the skull.

CHONDROMA.

A chondroma is a tumor composed of cartilaginous tissue. All the varieties of cartilage are found in neoplasms, the hyaline being the most common and the fibro-cartilage and reticular cartilage rare. Tumors of fibro-cartilage are usually found about the ligaments or in the salivary glands.

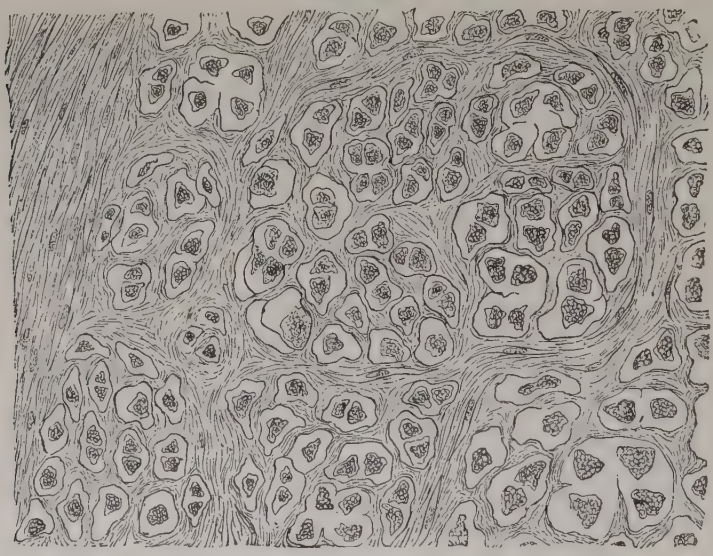
We must distinguish sharply between two classes of chondromata—those which spring from the normal cartilages or bones and those which originate elsewhere. In the latter case the tumors are seldom pure chondromata and often show malignant characteristics. In the first case, however, the tumors grow slowly, resemble epiphyseal cartilage in their structure, and are usually to be found in the neighborhood of the epiphyses. (Fig. 56.) In some curious cases they appear to be left anchored upon the shaft at the point where they first appeared, the epiphysis growing beyond them, so that the tumor which first appeared near the end of the bone is found later near the middle of the shaft. It has been shown that some small fragments of cartilage may be left behind in the ends of the long bones as the epiphyses advance, and they may remain without ossification, ready to form tumors later in life. This fact explains the frequent association of rickets with multiple chondromata, for irregular ossification is often observed in that disease. Chondroma most frequently begins in youth, when the bones are actively growing.

Occurrence.—About two-thirds of the chondromata originate from some part of the skeleton, and over one-half of these in the hand (Fig. 57)

and foot (Fig. 58). They are also common in the jaws. Chondromata growing from the costal or the nasal cartilages are usually small. Chondroma is also observed in the parotid, the breast, the testis, the ischio-rectal space, and the subcutaneous tissue, but it is seldom pure, being usually a part of the mixed tumors in the salivary glands or associated with sarcoma. The occurrence of pure chondromata in these regions is to be ascribed to misplaced fœtal remains, those in the parotid being derived from the ear or the branchial clefts. Chondromata are frequently multiple, and in some rare cases they are present in immense numbers, distorting the limbs and the jaws, displacing the eyes, and producing deformities which not only render the patient helpless, but may terminate his life.

Clinical Appearance.—The tumors are usually small, although they may attain a huge size. They form hard, rounded, smooth, or lobulated

FIG. 56.



Enchondroma from the knee-joint, × 300. (Agnew.)

masses, fixed to their point of origin, but without attachment to the surrounding parts. They grow slowly without pain or other symptoms except such as may be caused by their bulk or pressure, and they often become stationary. If they grow in the pelvis they may interfere with parturition. Spontaneous fracture may occur in the shaft of a long bone which has become atrophied by the pressure of a chondroma. When inflamed, necrosis and sloughing are apt to follow. Besides being liable to calcification and ossification, a chondroma may undergo gelatinous softening and become cystic. It also becomes sarcomatous in some cases. After an injury to a bone, for instance, a chondroma may appear and develop with some rapidity, and on removal it may return, and finally become sarcomatous in structure and form secondary tumors in the lung or elsewhere. Secondary deposits in the lymph-nodes and in the lungs are, however, sometimes seen in the true chondromata growing from bone. Multiple chondromata are

less apt to become malignant than single ones. Cartilaginous tissue often forms a part of other tumors, and especially of the so-called mixed tumors. The diagnosis between chondroma and osteoma will often be impossible in the epiphyseal tumors, but examination with a needle will enable one to recognize the former, as its point will penetrate it.

Treatment.—The majority of these tumors require no treatment, but if any operation is attempted they should be thoroughly eradicated. The pedunculated variety is easily removed, and will not return if the base be

FIG. 57.

Enchondroma of hand.

FIG. 58.

Chondroma of foot.

thoroughly gouged out. Those with broad bases, sometimes encircling a bone or originating from its centre, can be removed only by amputation. Rapid growth and softening indicate malignant change and the necessity for radical operations. The chondromata which arise independently of the normal cartilages, in the parotid, for instance, grow slowly, but are especially liable to malignant change, and should be removed unless there is great danger of injury to the facial nerve. If they show any tendency to rapid growth a very complete extirpation must be made for the same reason, not merely shelling the tumor out of its capsule. Chondroma of the upper jaw is especially liable to recurrence and final malignant changes, and therefore that bone should be sacrificed at the first operation.

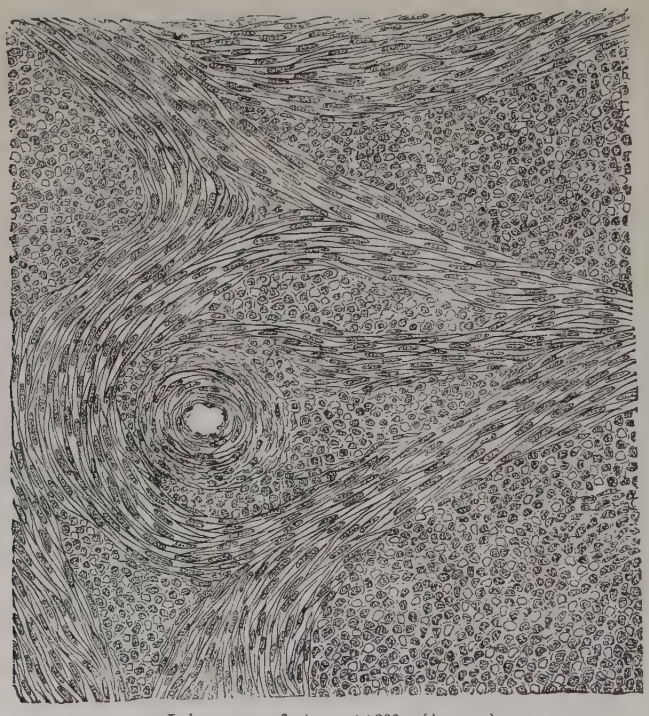
MYOMA.

A myoma is a tumor composed of muscular tissue. A tumor formed of unstriped or involuntary muscle is called a **leiomyoma**, and one of striped muscle a **rhabdomyoma.** The former is seldom found pure, being almost invariably associated with fibrous tissue, the muscular and fibrous cells being often so much alike that it is difficult to distinguish them. (Fig. 59.)

It is far more common than rhabdomyoma. The latter has recently been reported as occurring in a pure form in the testicle in infants or just after puberty.

Leiomyomata may originate from the muscular coat of the blood-vessels in any part of the body, but they are especially frequent in the uterus, arising from the muscular fibres, and also develop from the unstriped muscle of the intestinal tract or the stomach. Tumors of the uterus will

Fig. 59.



Leiomyoma of uterus, × 300. (Agnew.)

be more particularly considered under the head of the female genitals. Myoma of the *stomach* or *intestines* usually presents a tumor of considerable size, growing slowly and appearing under a healthy mucous membrane, tending to project into the interior of the stomach or bowel, and occasionally forming polypoid growths with a thick pedicle. Small multiple tumors of smooth muscle fibre occur in the skin, especially on the arms. Myoma seldom attains a large size except in the abdominal organs. It can be removed by operation.

NEUROMA.

Following the ordinary classification, we place here neuroma, but the very existence of a true neuroma is denied by many excellent authorities, the so-called neuroma being a fibroma arising from the *sheath* of the nerve or causing the general fibromatous thickening known as elephantiasis of the nerves, or plexiform neuroma, which has already been described. The term

neuroma should indicate a tumor composed of nerve-tissue, and some new production of nerve-fibres should be present, but this does not exist in the tumors just mentioned. In very rare cases some multiplication of the nerve-cells and axis-cylinders has been found, but these are pathological curiosities. According to the majority of authorities, the nodular swellings at the ends of the divided nerves in *amputation stumps* are merely fibrous masses growing from the sheaths, and do not contain any new-formed fibres. Some pathologists reckon glioma as neuroma, for it originates only from the true nerve-cells of the brain and optic nerves, although the large round cells of the tumor do not in the least resemble the source from which they spring. Pure glioma is such a rarity that we shall confine our notice of these tumors to the description of gliosarcoma.

ANGIOMA.

An angioma is a tumor composed of a mass of newly formed blood-vessels or lymphatic vessels. By the term angioma is generally understood a tumor of the *blood-vessels*, commonly called a **nævus**, a tumor of lymphatic vessels being known as a lymphangioma.

Structure.—Angiomata which arise from the blood-vessels may contain dilated capillaries or veins, or even arteries, for cirsoid aneurisms are technically arterial angiomata, although they are usually considered instances of local disease of the arteries. Cirsoid aneurism will be treated of in the section on blood-vessels. Angioma may be strictly encapsulated, but occasionally it extends without any distinct boundary into the skin, muscles, and subcutaneous tissue about it. It may involve only the most superficial layers of the skin, producing the so-called **port-wine mark**, but more usually the deeper layers are also attacked, and the ordinary nævus is produced. In the port-wine mark only the smallest capillaries are involved, without other changes than their dilatation and remarkable abundance. To this form the term **telangiectasis** is most properly applied. A **cavernous angioma** is one containing dilated, tortuous, and thickened veins, as well as capillaries, and resembles cavernous tissue in its structure, but sometimes the septa break down and the adjacent veins may form large cysts full of blood. When an angioma is encapsulated the blood enters it by a few small arteries, and leaves it by similar veins of normal structure, which pass through the capsule and are connected with the capillaries and veins within the tumor. Even when the tumor is not well limited, the transition from the normal vessels to those of the tumor is quite sharp.

FIG. 60.

Subcutaneous angioma: *a*, normal skin: *b*, dilated vessels of the tumor, cut across. × 100. (F. C. Wood, M.D.)

Angiomata are often associated with a large amount of loose fibrous tissue,

or, still more frequently, with fatty tissue, especially in the substance of the cheek, involving its entire thickness. The diagnosis of these varieties can be made by the fact that the ordinary angioma is entirely compressible, the newly formed tissue in the vascular walls being too thin to make any considerable mass, whereas if there is much fibrous or fatty tissue a tumor of considerable size remains even after compression. While angiomata occasionally develop later in life, the majority of them are congenital. In individuals past middle life small multiple angiomata of the skin are not uncommon, although they are, more strictly speaking, telangiectatic spots due to atrophy of the skin.

Fig. 61.

Angioma of cheek and of chest.

Occurrence.—Angiomata are most frequent in the skin. They are seen in the mucous membranes, where they often assume the form of a papilloma. They occur in the membranes of the brain, especially the pia, and also in the glandular organs, such as the liver and kidneys, being generally well encapsulated in the latter. Three-quarters of the cutaneous angiomata are found upon the head, a large number being on the face. (Fig. 61.) Those in the neighborhood of the lips are sometimes continuous with similar changes on the mucous membranes within the mouth.

Clinical Appearance.—Although these tumors are, as a rule, only an inch or so in diameter, they sometimes involve an entire limb or half of the trunk, and in these extensive cases all the tissues of the limb are apt to be affected, even the bones showing changes in their blood-vessels. (Fig. 63.) Sometimes the tumors are pedunculated, and this is perhaps more common in the neighborhood of the nose and ear and in the mucous membranes than in other situations. Even when tumors extend deeply, they usually involve the skin also, but in some cases the tumor is entirely below the fascia, and the skin over it is healthy. (Figs. 60 and 62.) The diagnosis is then often impossible, unless the venous blood of the tumor shows a blue tint through the overlying skin.

History.—Angiomata are generally observed at birth or soon after. They may remain stationary for years, or may spread slowly or rapidly. Rarely they disappear spontaneously. If injured, they bleed profusely and are liable to infection, and the intensity of the infection may cause a slough of all the vascular tissue and result in a cure by cicatrization, but the sloughing of such vascular tissues is not without danger to the patient, as it may give rise to pyæmia. While in general these tumors have a benign history, the possibility of extensive growth, hemorrhage, or infection, or the deformity they produce, makes prompt treatment advisable. We have seen one case end in death in a few months from rapid growth of an originally small angioma in which operation was not permitted. The diminished

frequency of cirsoid aneurism is ascribed by some to the more energetic treatment of angioma.

Treatment.—The various methods of treatment of angioma may be divided into three classes: first, entire removal by **excision** or destruction by the cautery; secondly, the production of **thrombosis** in the vessels by ligation at a distance, or in the tumor by injection of styptic fluids or transfixion by threads impregnated with styptic fluids; or, finally, the production of **cicatrization** by the induction of suppuration, by multiple scarification, by the actual cautery, or by electrolysis. The choice of the method of treatment will vary with the particular tumor to be treated, and with its situation. When the tumor is small or pedunculated, *excision* is probably the best method of treatment, for the edges of the wound can then be brought together without tension and only a slight scar is the result. The operation is not difficult if the incision is made through the healthy skin beyond the dilated vessels, and the hemorrhage will be no greater than in any ordinary wound. Excision is especially suited for angiomata of the scalp, for the blood-supply can be controlled in such cases by pressure with the assistant's hands around the tumor while the surgeon makes his incisions. Even upon the face excision is the best method of treatment, when the tumor is not extensive and narrow linear scars can be produced which correspond more or less with the natural wrinkles or folds in the skin. Destruction of the tumors by the **cautery** or **caustics**, such as nitric acid, should be reserved for very small tumors, on account of the slow healing and unsightly scars, but is the method preferred for such tumors by some surgeons. In the method of treatment by **thrombosis** we may act on the old suggestion to pass ligatures through the base of the tumor in the healthy tissue with the idea of constricting the blood-supply of the part, as explained

Fig. 62.

Extensive subfascial angioma of neck, not involving the skin.

Fig. 63.

Angioma of hand in a boy of fourteen years, advancing steadily and compelling amputation of a finger and finally of the hand.

on page 211. If the operation is done aseptically there is no very serious objection to the method, except the danger of causing extensive sloughing of the skin, and the ligature need not be tied tightly, for a very slight pressure is sufficient to control the blood-supply and to allow the vessels to be filled with clot. A very old method of treatment consists in the *injection of styptic substances*, such as the sesquichloride of iron, but this method is dangerous, because it forms clots in the vessels, and occasionally small clots may be washed away by the blood-current and occasion embolism. Far safer and very efficient is Esmarch's method of treating the tumor by styptic substances, which consists in passing sterilized stout silk threads wet with the iron solution back and forth through the substance of the tumor to the healthy skin about it, interlacing the threads in all directions. A large number of sutures should be passed at intervals of an eighth of an inch or a quarter of an inch, left in place for some days, and then withdrawn. Before any such operation is done, the parts should be rendered thoroughly aseptic, and suppuration along the course of the threads should be avoided by sterilizing the threads, instruments, and hands. If suppuration should set in, it may assist the cure, but there is danger of pyæmia, and an unsightly scar results, while if asepsis is preserved, the scar consists simply of punctate spots of cicatricial tissue. In the third class of methods also we endeavor to produce scar-tissue, and this may be done by exciting suppuration. **Vaccination**, for instance, has been practised directly on the angioma, and cures have thus been obtained, but the objection to inducing suppuration is that the infection is likely to travel beyond the part intended and to do more damage than the surgeon wishes. Another method of producing scar-tissue is multiple **scarification** by a sharp knife, a method which is suitable for superficial angiomata, the resulting hemorrhage coming from such small vessels that it is readily controlled by pressure. The cure is produced by the scars following the multiple incisions, the vessels being divided and obliterated at many points. The treatment by the **punctate cautery**, a red-hot needle being thrust repeatedly into the tumor, is based on a similar theory. An ordinary needle heated in the flame of a spirit-lamp may be employed, or, in the case of large angiomata, where a scar is not so important, the fine point of a thermo-cautery will answer. Finally, we may describe the treatment by **electrolysis.** The negative or positive pole is to be used according to the effect desired. If an attempt is to be made to cure the tumor by thrombosis only, the positive pole should be attached to the needle which makes the punctures, clots forming in the track of the needle, and the vessels being obliterated. If the negative pole be used, the tissue around the needle is actually destroyed by the current and cicatricial tissue produced, as in the method with the punctate cautery. In either case the other pole is attached to a large sponge electrode applied on the neighboring skin. The positive pole produces the smoother scar, but it is tedious and unreliable. The negative pole also requires frequent sittings, even if a considerable number of punctures is made at each sitting. The treatment is somewhat painful, but we prefer not to give an anæsthetic, as so many applications must be made. It is best suited for the port-wine mark.

The choice of the method of treatment depends upon the size and situa-

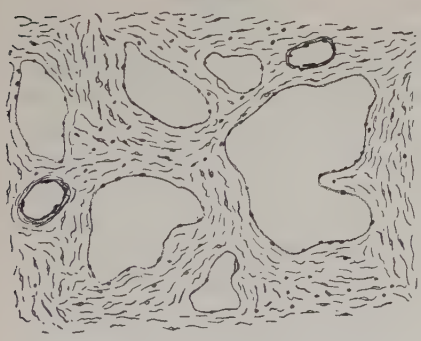
tion of the tumor. When it is small or has a narrow base it may be excised; and even large tumors may be so treated when a scar is not objectionable. Superficial tumors may be cauterized with acid or treated by punctate cautery or electrolysis, the latter being preferable when they are extensive. When the soft parts are extensively diseased and the tumor forms a considerable mass, Esmarch's method is the best plan of treatment.

LYMPHANGIOMA.

Lymphatic vessels produce the same varieties of tumors as the blood-vessels, and we may distinguish a lymphatic telangiectasis or capillary form, a cavernous form, and a cystic lymphangioma.

Structure.—The gross structure of the capillary and the cavernous lymphangioma exactly resembles that of the corresponding tumors of the blood-vessels, except that the vessels have thinner walls and cystic changes are more frequent. (Fig. 64.) The cysts of lymphangioma are produced by extreme dilatation of vessels in the tumor, with absorption of the walls between the adjacent distended vessels, the result being the formation of large irregular cavities connected at many points with the lymphatic system of the tumor. These cavities have a tendency to increase constantly at the expense of the surrounding parts. In some cases the lymphangioma will be found full of small cavities constructed in this way; in other cases the entire tumor may be converted into one large cyst, especially in the neck. Like the blood angiomata, the lymphangiomata are usually congenital in origin, and may extend slowly or rapidly. They are most frequently seen in the lips and the tongue, where they give rise to the deformities known as *macrocheilia* and *macroglossia*.

Fig. 64.



Lymphangioma, × 100. (F. C. Wood, M.D.)

Fig. 65.

Lymphatic cyst of neck. (Agnew.)

Lymphatic cysts of the neck have been given the name of hygroma colli cysticum, or *hydrocele of the neck* (Fig. 65), but the term cystic lymphangioma is preferable. In many of the branchial cysts there is an accumulation of round cells in the walls with a structure resembling that of a lymphatic gland or a lymphangioma, and, while it is possible that some supposed branchial cysts are really of lymphatic origin, the mere presence

of this lymphatic tissue proves nothing against the branchial origin of the cyst.

Treatment.—These cysts have been treated successfully by aspiration and the injection of iodine, but failures are common with this method. Extirpation, on the other hand, is generally very difficult, because these tumors originate in the neighborhood of the great vessels and nerves, and a preliminary attempt to cure the cyst by injection creates adhesions and adds to the difficulties. The ordinary lymphangiomata may be treated on the same lines as the tumors of the blood-vessels, but free excision is the best method of dealing with them.

ENDOTHELIOMA.

An endothelioma is a tumor composed of endothelial cells in a stroma of connective tissue. In pathological structure and in clinical significance it stands midway between the connective-tissue group and the epithelial tumors.

Structure.—The tumors originate in the endothelial cells which line the blood-vessels, the lymphatic vessels, and the lymphatic spaces in the connective tissue, and which cover the serous and synovial membranes, so that they are very widely distributed and of varying structure according to the tissue from which they have sprung. Formed from the endothelium, they belong to the group of connective-tissue tumors, but the rapidly proliferating cells of which they are composed bear so close a resemblance to the cells of epithelial growths that the diagnosis is exceedingly difficult, and in some cases impossible. The tumor called cylindroma was supposed to be the product of epithelial cells growing in convoluted tubes, but is undoubtedly an endothelioma, the tubes representing the vessels in which the cells have grown. The characteristic cells in these tumors are large, with a large nucleus, irregular in shape, flattened, or almost cylindrical, or globular. They are contained in a stroma of connective tissue, which may be scanty or may form spaces containing the cells. These spaces often form convoluted tubes, in which one may trace the winding of the vessels as in an angioma, and in other cases they form cavities closely resembling the acini of an acinous gland. The boundary-line between angiosarcoma and endothelioma is difficult to define, and it is probable that the latter often changes to sarcoma.

Varieties.—The important varieties of endothelioma are those of the skin, the serous membranes, the breast, and the ovary.

Endothelioma of the skin has the tubular structure which has already been mentioned, and forms small, flat nodules in the corium or limited to the papillary layer, with little tendency to ulceration. The tumors are generally small and multiple. Endothelioma growing from the *serous membranes* may show itself merely as a flat mass formed by hypertrophy of the endothelial layer, or many layers of these cells may form a thick wart-like protuberance upon the surface of the serous membrane. In other cases tumors of the cylindroma variety are found, making hard nodules which may attain a considerable size, although they are seldom more than half an inch in diameter. Such tumors occur in the peritoneal cavity and in the arachnoid.

Endothelioma of the breast may closely resemble carcinoma. The tumors are usually superficial, grow very slowly, with few symptoms, and seldom attain a large size. The lymphatic glands are not involved, the skin is generally not adherent over the tumor, and there is little tendency to ulceration. The diagnosis from carcinoma can be made by the exceedingly slow growth of endothelioma, its encapsulation, and the freedom of the axillary glands. In some cases, however, these tumors have a course like that of sarcoma.

Endothelioma of the ovary is a small tumor, usually of the cylindroma type, and is rare. It has none of the characteristics of sarcoma in this region, and is usually discovered accidentally.

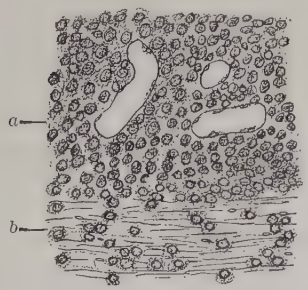
Clinical History.—The clinical history of endothelioma can be deduced from the above, the tumors growing slowly, with little tendency to ulceration or invasion of surrounding parts. But they represent a type of those suspicious tumors which are liable to become malignant, especially under the stimulation of injury or irritation.

Treatment.—A doubtful tumor of this character should most certainly be extirpated, but the operations need not be so extensive as those for malignant disease. In the serous cavities of the peritoneum and brain the tumors are usually very small, and not likely to produce symptoms serious enough to demand operative interference, although in the brain they may give rise to serious pressure symptoms.

SARCOMA.

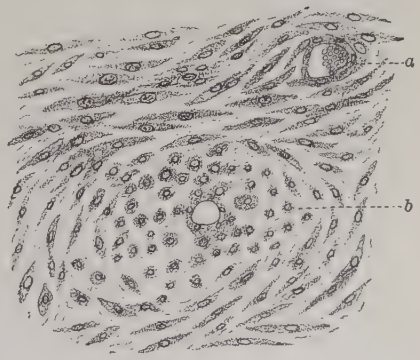
We have considered the tumors which spring from the mesoblast and resemble in structure the various tissues which descend from that layer, but there is a group of tumors of similar origin which do not resemble any tissues found in the adult body, except the granulation-tissue found in the repair of wounds and in inflammation. The last-mentioned tumors are of various structure, but they all resemble the different forms of fœtal connective tissues, tissues therefore which are normal in the fœtus, but abnormal in adult life. A sarcoma may be defined as a tumor composed of embryonic tissues of mesoblastic origin. It is always malignant, although

Fig. 66.



Small round-cell sarcoma: *a*, small round cells and thin-walled vessels; *b*, capsule of tumor infiltrated with cells from the tumor. (F. C. Wood, M.D.)

Fig. 67.

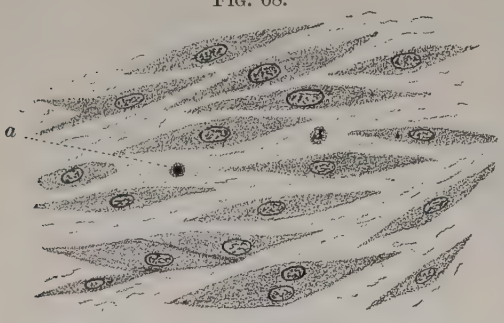


Small spindle-cell sarcoma: *a*, blood-vessel; *b*, transverse section of spindle-cells. (F. C. Wood, M.D.)

its malignancy varies greatly in degree. The embryonic tissue is often found associated with fully developed tissues, and the malignancy of any tumor in which both tissues occur corresponds to the proportion between the two, for the more of the fully developed and adult tissue the tumor contains the less is its malignancy.

Structure.—Sarcomata are formed of cells of varying shapes, always embedded in an intercellular substance, although in many cases the latter is very delicate and can be seen only by removing the cells from its meshes. The tumors are vascular, and the capillaries have very thin walls. (Fig. 66.) The walls of the vessel may be formed of endothelial cells lying directly upon the cells of the tumor, or they may be entirely absent, and the blood may flow in channels between the cells of the tumor. The tumor is often partially encapsulated, but the abnormal cells usually infiltrate the capsule somewhat. (Fig. 66.) The cells of these tumors are round or spindle-shaped, or giant-cells. The round cells may be small or large, most frequently the former. In either case the nucleus is very large and nearly fills the cell body. The small round-cell tumors (Fig. 66) resemble granulation-tissue very closely, and often cannot be distinguished from it except by the fact that granulation tends to the production of normal adult connective tissue, while the growth of sarcoma remains embryonic. The spindle-cells are usually small (Fig. 67), but they may attain a very large size, and the intercellular substance may be very scanty. (Fig. 68.) The giant-cells are multinuclear cells of large size, similar to those seen in actively growing bone. (Fig. 69.) These cells are most frequently found in sarcomata with a tendency to produce bone (Fig. 71), but their function seems to be the absorption of the newly formed bone. In some tumors any or all of these various cells will be found combined, and the name of *mixed-cell sarcoma* has been applied to them. All these varieties of sarcomatous tissue are often found associated with tissues of a higher type, fibrous tissue, cartilage, bone, fat, and myxoma being very frequently combined with them: hence the names fibrosarcoma, osteosarcoma, myxosarcoma, angiosarcoma, etc. (Figs. 70 and 71.)

FIG. 68.



Large spindle-cell sarcoma: *a*, leucocyte. × 300. (F. C. Wood, M.D.)

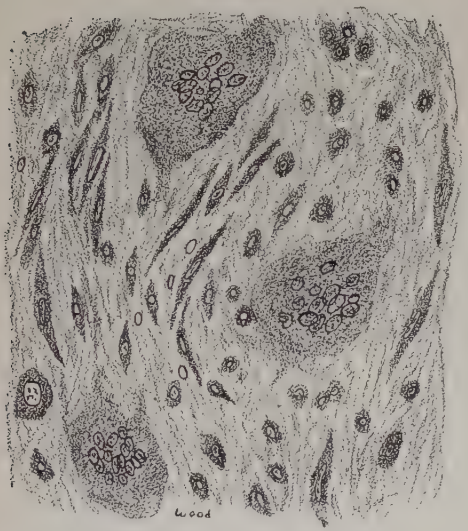
Gliosarcoma.—Gliosarcoma is a variety of round-cell sarcoma with large cells, containing a large nucleus, springing from the neuroglia of the nerve-centres, and found only in the brain and in the eye. They are encapsulated at first, and do not generally grow rapidly or tend to metastasis. Their chief claim to malignancy is their situation, where even a benign tumor is dangerous. They may attain a considerable size, although usually not larger than a walnut. When removed they are apt to return, for the diagnosis is seldom made until the tumors are well grown and invasion of

the surrounding tissues has begun. For their treatment we refer to the sections on tumors of the brain and of the eye.

Alveolar Sarcoma.—Alveolar sarcoma is a form in which the intercellular substance is increased in some of its strands and so arranged as to form alveoli containing groups of cells and resembling carcinoma. The cells are round or spindle-shaped, most frequently the former. An intercellular substance can generally be demonstrated, although it may be very scanty, and serves to distinguish these neoplasms from the epithelial tumors. It seems probable that the round-cell alveolar sarcomata are of endothelial origin, the walls of the vessels or lymph-spaces forming the alveoli and the cells originating from their endothelial lining.

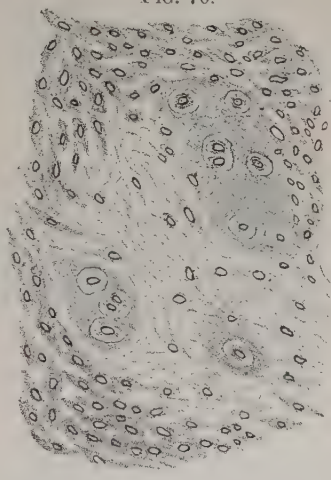
Melanotic Sarcoma.—Deposits of pigment are found in round-cell and spindle-cell sarcoma, and occur both in the cells and stroma. The

Fig. 69.



Giant-cell sarcoma, × 300. (F. C. Wood, M.D.)

Fig. 70.

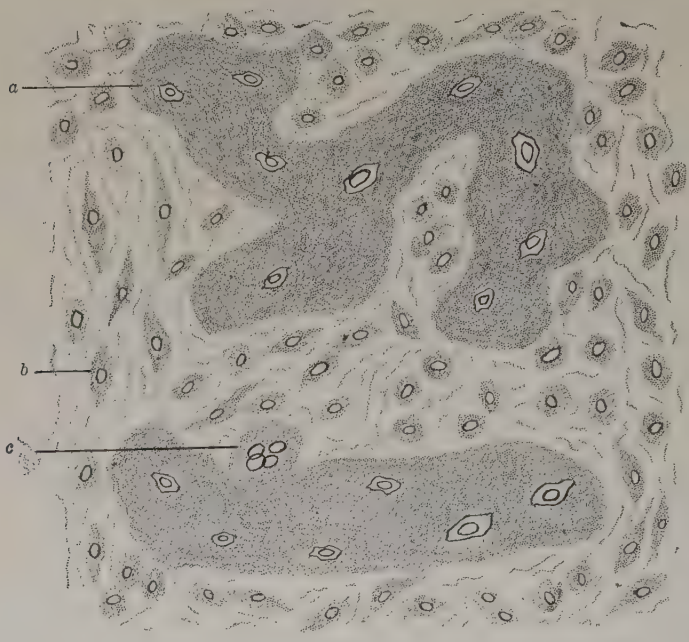


Myxochondrosarcoma of parotid. (F. C. Wood, M.D.)

presence of pigment generally indicates a more malignant type of tumor, although over ten per cent. of the cases have remained well after operation, so that the prognosis is not hopeless. Melanotic tumors do not otherwise differ from the other sarcomata. They occur at all ages, and in both sexes, but more frequently in men. They develop where pigment occurs normally, in the choroid coat of the eye, and in the skin, frequently originating from a congenital mole. The lymphatic glands are affected in at least one-fifth of the cases, and sometimes the primary tumor develops in a lymph-node. Without operation the disease runs its course in less than eighteen months, but occasionally the tumors appear to have a very slow growth. Secondary deposits in the deeper organs are the rule, and in advanced cases the urine may be discolored by elimination of the pigment by the kidneys, showing that the coloring-matter finds its way into the circulation, probably by means of the cells, which enter it and disintegrate in the blood.

Metastasis.—The metastasis of sarcoma takes place by the growth penetrating the blood-vessels, infection of the lymphatic system being infrequent, although it is more common than usually supposed, as the glands have been found to be involved in about one-sixth of the cases of sarcoma of the breast. When the wall of a vein is attacked by the growth, a bud

Fig. 71.



Osteosarcoma of humerus: *a*, lamellæ of bone; *b*, spindle-cell of the sarcoma; *c*, giant-cell acting as an osteoclast and causing absorption of bone. (F. C. Wood, M.D.)

of sarcomatous tissue forms on its inner surface, and small particles or single cells may be swept away by the blood-current to other parts of the body, giving rise to secondary tumors wherever they are arrested, the dissemination resembling that of pyæmia. (Figs. 72 and 73.) An embolus from such a tumor must pass the minute capillaries of the lungs before again entering the general circulation so as to cause secondary tumors elsewhere,

Fig. 72.

Metastatic sarcoma of clavicle secondary to sarcoma of thigh, for which amputation had been performed.

and this accounts for the frequency with which secondary tumors occur in the lung. It is not easy to explain how they ever escape, and yet the lungs are often found to be healthy even when secondary tumors are present else-

where. In addition to true metastasis by the blood-vessels and the lymph-vessels, a sort of transplantation may occur in a sarcoma growing from one of the serous surfaces of the body, as, for instance, the peritoneum, which may give rise to growths elsewhere in that cavity by fragments or cells, which are detached from its surface and implanted in other parts of the serous lining.

FIG. 73.

Metastatic sarcoma of groin secondary to sarcoma of neck. (Dr. R. Abbe.)

Occurrence.—Sarcoma is found in all the organs and tissues of the body, the bones, skin, testicles, ovary, breast, and uterus being most frequently involved. Multiple sarcoma is found in the skin in the form of numerous small growths scattered over the body, and its course is rather a slow one, although it progresses to a fatal termination, the tumors finally ulcerating, and internal secondary deposits taking place. Sarcoma of the skin, however, also occurs in single tumors, which often arise from a wart or congenital mole, and these may be very malignant, not merely making large tumors locally, but spreading very rapidly to other parts and forming metastatic deposits.

Clinical Appearance and History.—The clinical history of sarcomata is not easy to sketch, on account of the variations in the different types. Sarcoma is found at all ages, but is more frequent from puberty to the thirtieth year of life. In general it may be said that sarcoma grows very rapidly, and remains partially encapsulated from the surrounding tissue. It is very vascular, and its growth is apt to be painful, but ulceration does not, as a rule, set in until late, although if the tumor be very prominent the skin over the surface may slough in consequence of injury or because its blood-supply is interfered with. This sloughing is unlike the ulceration occurring with carcinoma, in which the skin actually becomes involved in the epithelial growth and then breaks down. When an opening has thus been made in the overlying tissues the capsule yields, and the tumor is apt to project through it in a mass of cauliflower shape. In sarcoma of the internal organs a rise of temperature in irregular curves resembling pyæmia or tuberculosis or even typhoid fever often takes place; and a local rise of temperature is not uncommon in sarcoma, a difference of as much as one degree having been detected by the surface thermometer. The symptoms produced by the tumor depend upon its situation, and they will be described in connection with the different organs.

The course of a sarcoma depends largely upon its structure: thus, the round-cell sarcomata (especially if the cells are small) are more malignant than the spindle-cell tumors, and both of these are more malignant than the

giant-cell variety. The presence of fibrous tissue or of true bone in a sarcoma also renders the prognosis better. The duration of sarcoma seems to be a very variable one. Some tumors run a course of great rapidity, the growth spreading through the tissues almost as rapidly as a purulent infiltration, and secondary tumors appearing at once in distant organs. Others resemble a fibroma, growing very slowly, being encapsulated, giving absolutely no symptoms, and sometimes remaining stationary in size and without dissemination elsewhere for years, until a blow or some unknown cause brings out their malignant character. It is as yet uncertain whether these latter tumors are sarcomatous from the first or whether they are benign tumors in which a sarcomatous change takes place.

Diagnosis.—The diagnosis of sarcoma is to be made when a well encapsulated tumor originates from some part of the body which does not contain epithelial cells and grows rapidly, especially if it directly follows a severe injury. If the tumor is subcutaneous, the skin will not be involved or even adherent until late in the disease. If it originates in the skin, it may be learned that a wart or mole existed previously in that situation. The diagnosis may be made certain by excluding benign tumors, inflammatory swellings, and epithelial tumors. The first can usually be done by the short duration and rapid growth of sarcoma, and occasionally by its less distinct encapsulation. The diagnosis from inflammatory swellings is not always easy, because the

Fig. 74.

Myxosarcoma of thigh.

Fig. 75.

Osteosarcoma of femur.

rapidly growing sarcomata are sometimes marked by local heat and acute, throbbing pain, but the lack of infiltration in the neighborhood of the ordinary sarcoma will distinguish it sufficiently from inflammatory disease, and its growth is rarely so rapid as that of inflammation. The principal difficulty will be found in the chronic inflamma-

Fig. 76.

Osteosarcoma of pelvis. (Dr. R. Abbe.)

Fig. 77.

Osteosarcoma of scapula.

tions, such as syphilis, actinomycosis, and tubercle. The recognition of epithelial growths will depend largely upon the fact that such tumors must take their origin from epithelial tissue, and primary epithelial tumors cannot occur in the bones or the lymphatic glands, nor are they so frequent in the subcutaneous tissue as sarcomata. A sarcoma generally presents more or less rounded surfaces of varying consistency, hard in one part and soft in another, and the tumor is usually partly encapsulated, and often movable at first, whereas the epithelial growths are generally of stony hardness, and liable to become adherent to the skin or mucous membranes even before the latter are actually involved. Enlargement of the glands in the early stages indicates that the growth is epithelial, although this rule is not invariable, nor is the age of the patient altogether to be relied upon, for sarcoma may appear late in life, although it is much less common than the epithelial tumors at that period. In many cases the excision of a fragment by the knife or by Warren's punch for microscopic examination will be the only means of determining the real nature of these growths. Positive evidence of malignant disease may be thus obtained, but if the result of the examination is negative it should be accepted with a certain reserve, because the examination of small portions is not always satisfactory, for the tumor may vary in structure in different parts.

Treatment.—Thorough **extirpation** is the only effective treatment for

sarcoma, and the neighboring glands of the region should also be removed, even if no visible sign of disease is present. In the case of sarcoma of one of the extremities, amputation is often necessary, in order to remove the tumor or because its complete removal would leave a useless limb. If attempts are made to extirpate the tumor and save the limb, the surgeon is apt to err on the side of conservatism. When the long bones are involved, the entire bone should be removed at the joint above, whether the tumor be periosteal or central. It is true that the giant-cell tumors seem to be rather less malignant, and a cure has been obtained in some cases by partial removal of the bone. The many failures observed in the treatment of malignant tumors by the most thorough operations, however, indicate that prudence should compel us to do too much rather than too little until our means of controlling this disease improve. Resection of the shaft of a bone, therefore, cannot be recommended, nor amputation through the middle of a long bone, even when the distal extremity only is involved. Large doses of arsenic have been used in the treatment of lymphosarcoma, and hypodermatic injections of that substance into the glands have been made, but cures have very rarely been obtained.

Erysipelas-inoculation.—A considerable number of cases are on record in which sarcoma or carcinoma has disappeared after attacks of erysipelas, and the effect of erysipelas in producing this result cannot be denied. Attempts have been made to utilize this effect by inoculating patients with erysipelas, but the results were uncertain and the risk was considerable, the erysipelas being very difficult to control and often ending fatally. On the supposition that the effects of erysipelas upon malignant tumors were due to the toxines of the streptococcus which caused the inflammation, attempts have been made to produce similar effects by injecting a sterilized pure culture into the tumor. Coley finds that the addition of a culture of the bacillus prodigiosus to the injected material increases the effect. The result of these injections is a severe chill and a rise of temperature, but no inflammation is set up if the injections are sterile. In a few cases sarcomata have been observed to disappear after these injections, but the method of treatment has proved very unsatisfactory, and the majority of surgeons of experience think the results are too uncertain to warrant the necessary risk. In cases suitable for operation the method should not be thought of, as operation gives far better results, but in tumors which cannot be removed it may be tried as an experiment, although it must be remembered that the weakening effect of the treatment is very great and that death may be hastened by its use.

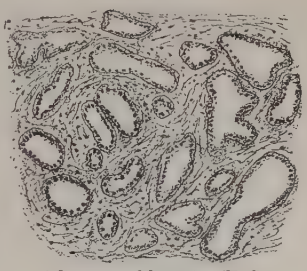
ADENOMA.

An adenoma is a tumor consisting of epithelial cells and a fibrous stroma simulating the structure of the gland in which it occurs, and it may be tubular or acinous. Some authorities call tumors of the lymphatic glands lymphadenomata, just as the term adenitis is applied to their inflammation, but this nomenclature should be altered, as the lymphatic glands are mere aggregations of lymphatic tissue and not true excreting or secreting glands, and we shall limit the term adenoma to epithelial tumors. In simple hyper-

trophy of a gland there is an increase in the amount of the glandular tissues, but they retain their functional powers, while in adenoma the cells are without function and there are no ducts. An adenoma is usually encapsulated and distinct from the gland-tissue, but sometimes the entire gland may be involved in adenomatous degeneration, and in such cases it is not easy to distinguish the neoplasm from simple hypertrophy. With the exception of the ovarian or thyroid cysts, the tumors are not of large size.

Occurrence.—Adenoma is common in the glands of the mucous membranes, and is also found in those of the skin. It frequently occurs in the thyroid, the ovaries, the mamma, the testicles, and the rectum, and less commonly in the kidney and the liver.

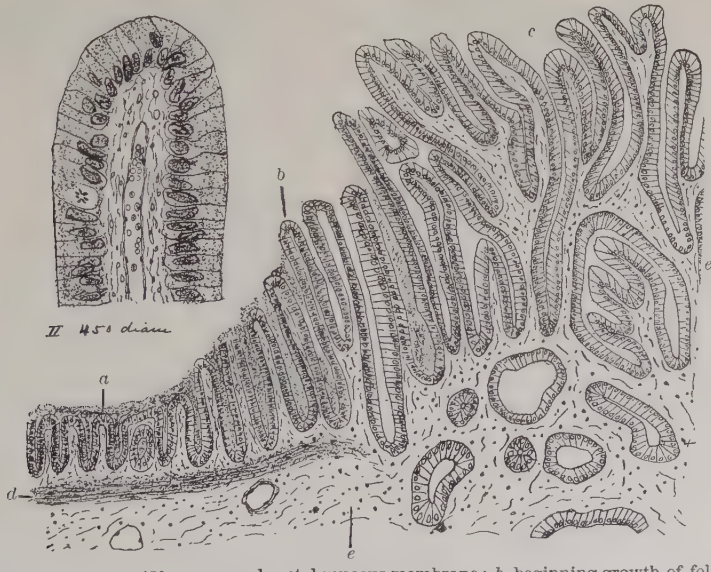
Fig. 78.



Adenoma of breast. (F. C. Wood, M.D.)

Structure.—The structure of adenoma is seldom exactly like that of the gland from which it springs, adenoma of the kidney being a simple tubular glandular structure, quite different from the convoluted tubules of the kidney, and adenoma of the intestine being far more complicated than the Lieberkühn's glands from which it originates. In the breast the structure looks like normal mammary tissue, except that there are no ducts (Fig. 78); but pure adenoma of the breast is rare, the tumors generally being largely composed of fibrous tissue. In some cases the intestinal adenomata are polypoid in shape and are quite benign, but in others the

Fig. 79.



Adenoma of rectum, × 150: *a*, normal rectal mucous membrane; *b*, beginning growth of follicles of the mucous coat; *c*, irregular growth forming adenomatous tissue and penetrating the submucosa, *e*; *d*, muscular coat; *e*, submucosa; II., a part of the gland marked *b*, × 450.

newly formed tubular tissue tends to invade the neighboring mucous membrane (Fig. 79), and, although the cells do not penetrate the basement mem-

brane upon which they rest, the tumor is analogous to carcinoma in its active growth and its tendency to recurrence and even to metastasis. In the kidney and liver the adenomata form well encapsulated tumors, seldom attaining a large size. In many of these epithelial tumors it is impossible to draw a sharp line between the benign and the malignant. Adenoma of the thyroid gland (which is described in the section upon the thyroid) not infrequently causes metastases in spite of its innocent structure, the secondary tumors being formed most commonly in the bones and having the histological appearance of the normal thyroid. The ovarian adenoma also sometimes resembles a malignant tumor, for its proliferating or papillomatous form is capable of infecting other parts of the peritoneal surfaces and causing the growth of similar tumors there.

Adenoma is very liable to cystic changes, as is natural in a glandular structure without excretory ducts to carry off its secretions and degenerating epithelium. The sebaceous cysts are reckoned by some pathologists among the adenomata. Hemorrhages frequently occur in these tumors, and myxomatous degeneration of the stroma may be found. A change to carcinoma easily takes place and is not uncommon.

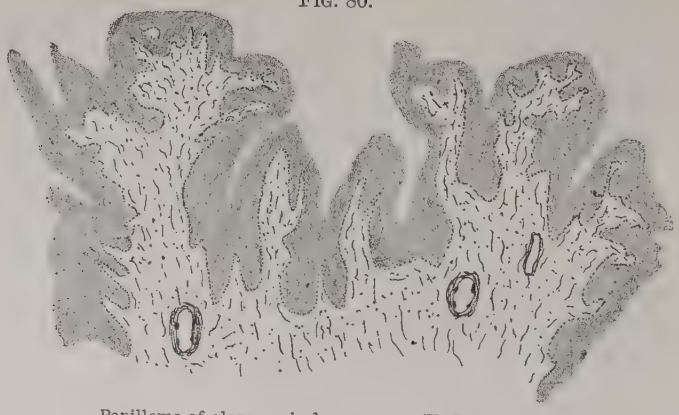
Clinical Appearance.—The tumors vary so much that we refer to the descriptions in the accounts of various organs in which adenoma occurs.

Treatment.—The treatment of adenoma is removal by operation, on account of its great liability to malignant degeneration.

PAPILLOMA.

Structure.—While adenoma is a benign epithelial tumor in which the epithelial cells are enclosed in a fibrous stroma, papilloma is a similar growth in which the stroma forms an inside skeleton, covered by the epithelial cells like the ordinary papillæ. The papillæ grow in various shapes, sometimes

FIG. 80.



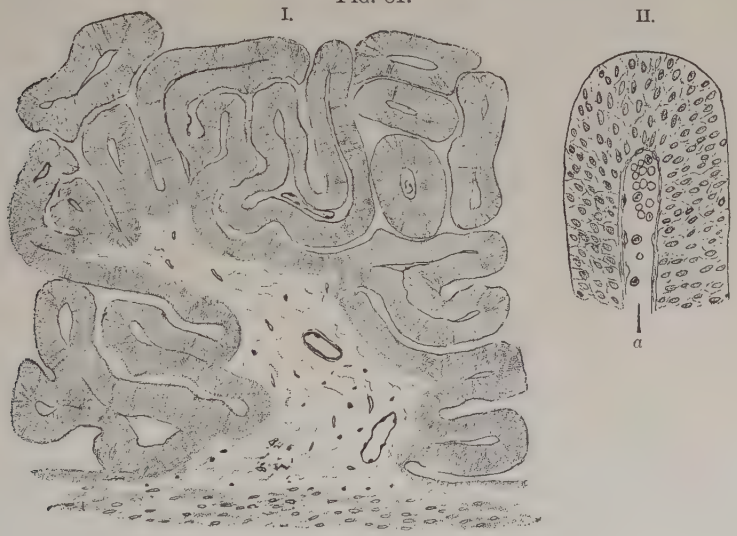
Papilloma of glans penis, low power. (F. C. Wood, M.D.)

rather broad and flat, sometimes in large masses with a narrow pedicle like a cauliflower (Fig. 80), sometimes with long fimbriated extremities growing from a common broad base, the last-named form being called *dendritic*, from its resemblance to a tree. Every papilla in the growth contains a loop of a

small blood-vessel—a formation which explains the frequency of dangerous hemorrhage, especially in the papillomata of a very soft mucous membrane like the intestine or the bladder. (Fig. 81.) The growths differ in the thickness of the layers of epithelium over the papillæ, the thickened epithelial coat sometimes forming the principal mass of the tumor, while in other cases it is very thin and the mass is formed by the large fibrous bodies of the papillæ.

Occurrence.—Papillomata are found in regions where papillæ normally occur, such as the skin and mucous membranes of the body. They are common on the skin in the form of the ordinary wart, in the larynx, in the bladder, and in the rectum. The frequent association of papillomata

FIG. 81.



I., Papilloma of urinary bladder, × 50; II., one of the villi of I., highly magnified: *a*, central blood-vessel. (F. C. Wood, M.D.)

about the genital tract with a venereal disease which causes an irritating discharge shows very clearly the influence of chronic irritation in producing these growths. Their common occurrence in the larynx of singers is another proof of the same effect.

Clinical Appearance.—The growths may be single, but more frequently they are multiple, and sometimes they occur in very large numbers. On the skin they may cover the entire hand or the genitals, and in the larynx they may block the organ completely. Multiple papillomata are also the rule in the rectum. In the bladder they occasionally attain a large size, but their bases are usually small. They may be warty or polypoid in shape.

History.—On the skin their presence has no clinical significance, but on the genitals they retain the secretions of the parts. In the larynx they may completely obstruct the opening, and even minute papillomata upon the edges of the vocal cords may interfere with their movements and cause hoarseness and loss of voice. In the rectum they are serious mainly from the discharges which they excite. Papilloma of the bladder is one of the

most dangerous of these growths, often filling the entire bladder, and sometimes sending processes down the urethra even to the meatus, and the severe and frequent hemorrhages which take place from its surfaces occasionally result fatally. Papilloma is essentially a disease of youth, although it may develop at any age. The multiple form in the larynx is seldom found except in children. Papillomata may slough if their nutrition is cut off by traction or twisting of the pedicle. In other cases they disappear spontaneously through causes which are not understood, and it is not uncommon to see a crop of warts develop and persist for some months upon the hands of children and then suddenly disappear. Like all epithelial growths, the papillomata are liable to **malignant degeneration** as the result of continued or increased irritation. The change most naturally results in the formation of an epithelioma, the epithelial cells beginning to burrow into the basement membrane, and the process of cornification which belongs solely to the superficial cells affecting the entire thickness of the epithelial layer. Clinically these changes are marked by induration of the base of the tumor and by a tendency to ulceration and hemorrhage. Papilloma is also liable to sarcomatous degeneration owing to changes taking place in the fibrous parts of its structure, and this is especially true of those papillomata in which the fibrous tissue approaches a myxomatous character.

Treatment.—The mild caustics, such as strong acetic acid, may first be tried, and if they are ineffectual nitric acid should be employed to remove the growths. In papilloma of the genitals it is rarely necessary to do more than apply pulverized bismuth, or boric acid, or some astringent powder, such as calomel, dermatol, or aristol, after the proper attention to cleanliness, for cleanliness alone and the arrest of any genital discharge will cure the majority of cases. Ligation of the pedicle has been recommended in order to remove these tumors, but it should not be employed, because there is danger of infection from the mass as it sloughs away. It is far better to excise the tumor and ligate any bleeding vessel which may be found. The treatment of papilloma of the larynx, bladder, and rectum is described in their proper chapters.

CARCINOMA.

Carcinoma is a tumor formed of epithelial cells contained in irregular alveoli formed by a fibrous stroma, and characterized by a tendency to perforate the basement membrane upon which they grow and to invade the surrounding tissue. These tumors vary in the arrangement of the stroma and cells, and their structure and the character of their epithelium correspond to those of the part from which they originate.

Pathology.—By studying the edges of old ulcers of the legs, and the glands of the lips in the aged, or seborrhœic patches on the face, all the changes from normal epithelium through the stages of irritation to that of malignant degeneration can be distinctly traced.

One of the earliest changes in the epithelial cells tending to produce these growths appears to be a premature cornification. The most superficial layers of the epithelium of the skin become hardened and flattened with age, and Ranvier ascribes this cornification to the production of a substance

called *eleidin*. When a malignant change begins in the cells it is found that this substance has been produced and that cornification has taken place even in the young epithelial cells of the deeper layers. Under these circumstances the young cells are irregular in shape and have a marked tendency to rapid reproduction, as is indicated by the usual signs of karyokinesis. But the most significant change is the tendency of the newly formed cells to penetrate the basement membrane and to extend into the corium of the skin or into the submucous layers in solid masses. When this stage is reached the transformation is complete and the cancer has begun. Clinically these changes show themselves by a hardening and thickening of the tissues, by a tendency to ulceration or the formation of dry scabs on the surface, and by the extension of the infiltration beyond the original mass, and it is by these signs that the diagnosis must be made. The induration is quite different from that of ordinary inflammation, being more marked, having no trace of œdema, and its outlines being very sharply limited.

Carcinoma extends by a growth of the epithelial cells into the surrounding tissue on all sides, there being usually no trace of encapsulation, but the method of this extension is not yet understood. The epithelial cells multiply by karyokinesis, like normal cells. There is a zone of small round-cell infiltration, which usually spreads beyond the most advanced line of epithelial cells, and a similar round-cell infiltration is seen in the stroma of the tumor, especially when it is growing rapidly. These small round cells are probably of connective-tissue origin, and indicate an inflammatory reaction of the tissues against the epithelial invasion. The growth of the epithelial cells in the alveoli of the tumor is out of proportion to their blood-supply, and the central cells of each mass are so far removed from the vessels in the stroma that they are insufficiently nourished and are liable to break down and produce softening or ulceration. This degeneration may be fatty, colloid, or myxomatous, and may involve the stroma as well as the epithelial cells. Cysts may be formed in the tumor by this degeneration. If the tumor grows in the secretory glands it may exert pressure upon the ducts and cause retention cysts. Cystic carcinoma is especially in danger of inflammatory changes, but all carcinomata, on account of their poor blood-supply and insufficient nutrition, are liable to inflammation, and to very rapid and extensive destruction in consequence.

Metastasis.—These epithelial tumors have a strong tendency to spread in the lymphatic spaces and lymphatic vessels. They may extend along a lymphatic vessel to the nearest lymph-node, making a continuous growth of malignant tissue. Or a cell of the tumor may be carried on like an embolus and pass directly through the lymphatic vessels without contaminating them, as water might pass through a pipe, and attack the next lymphatic gland. When the gland is infected with the disease the epithelial cells grow freely in it, penetrate its capsule, and attack the surrounding cellular tissue, and they also spread onward through the lymphatic vessels to the next lymph-node above. This is the most common method of extension of malignant epithelial growths; but they also invade the blood-vessels, like sarcoma. In such cases the wall of a vessel, usually a large vein, is attacked by the tumor, and the epithelial cells grow into the lumen of the

vessel, producing a projection at that point, from which isolated cells or clusters of cells may be detached by the blood-current and carried into the circulation, and thus graft the tumor-tissue in different organs.

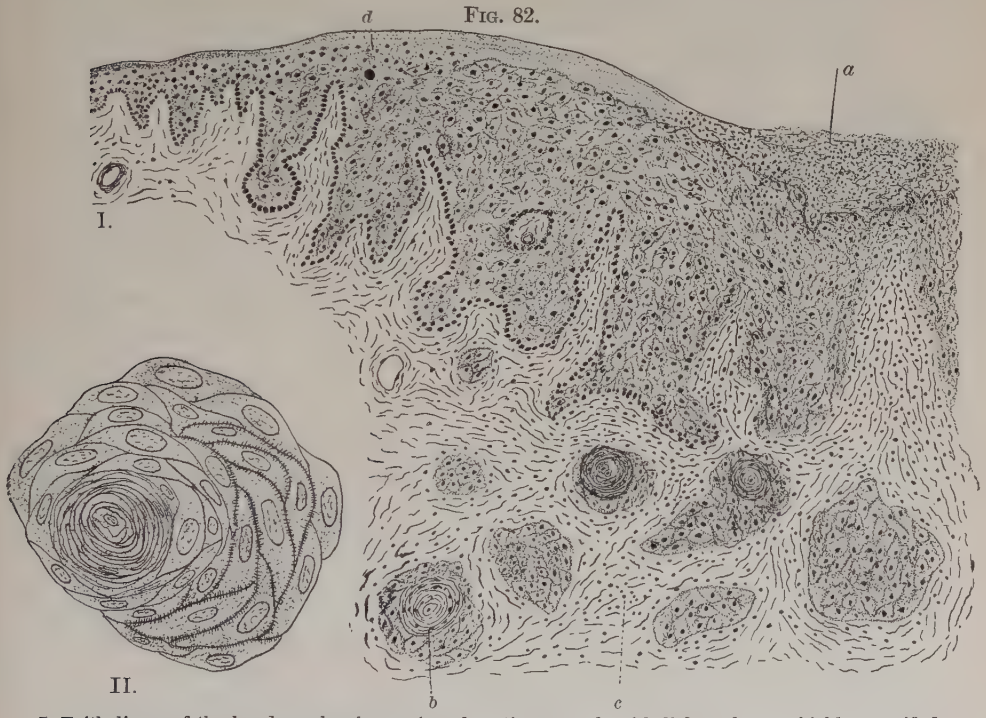
The vessel involved is usually one of the veins of the general circulation, and the blood must pass through the right side of the heart and be filtered through the lungs: hence tumors of the lungs are very frequent, the infecting cells being caught in the capillaries. Not infrequently, however, the embolus passes the capillaries of the lung and goes onward to the other distant organs, passing through the heart a second time. It is most frequently arrested in the liver, in the bones. and in the brain, but no part of the body is entirely exempt from secondary tumors. The liver, however, has a double danger if the tumor be situated in the region of the portal circulation, for an embolus may also be detached from the tumor in those vessels and be arrested in the portal capillaries of the liver. It is not yet understood why the infection passes through the lung in some cases without involving it, while in others it is arrested at this point. In order to traverse the capillaries of the lung the masses which convey the infection must be very minute, as an ordinary epithelial cell would be arrested in them unless it had the power of amœboid movement. It is possible that the conditions for the growth of these cells in the lung capillaries are not so favorable as elsewhere, for the proportions of oxygen and carbonic dioxide, not to mention the more complicated compounds of the blood, are very different in the pulmonary circulation. A purely mechanical explanation has been given by some, who assume that the foramen ovale has remained open, and that in this way the cells have passed directly from the right side of the heart to the left without traversing the pulmonary circulation; but, even granting that this condition is present in a larger proportion of cases than is usually supposed, the number remains so small that this explanation can hardly be accepted.

Varieties.—The principal varieties of carcinoma are epithelioma, tubular carcinoma, and acinous carcinoma.

Epithelioma.—Epithelioma is a tumor formed of flat ("pavement," "squamous") epithelial cells growing in globular or cylindrical masses, the cells at the centre of each mass being closely compressed and degenerated, forming the so-called "epithelial pearls" in the fully developed tumor. (Fig. 82.) A section through these pearls shows concentric zones of cells like the layers of an onion, the degenerated central cells being converted into a cheesy mass. Two-fifths of all the malignant epithelial growths are of this structure. Epithelioma occurs wherever flat epithelium is found, on the skin, the lips, the tongue, and in the œsophagus, larynx, vagina, cervix uteri, and urethra. Nearly three-quarters of the tumors occur on the face and lips. Epithelioma may also develop in the deep tissues of the neck from small dermoid cysts or fœtal remains, and on the internal surface of ovarian dermoid cysts. Epithelioma which develops from congenital moles, warts, or nævi of the skin is very malignant, but when it originates from warts which have appeared later in life or from such conditions as chronic ulcers, lupus, and scars, it is the least malignant of these tumors. (Fig. 83.) Melanotic epithelioma is quite rare, even rarer than pigmented sarcoma,

and it is usually rather more malignant. Epithelioma of the **tongue** grows rapidly, and has a strong tendency to spread beyond that organ, but in all other situations epithelioma grows slowly, invades the lymphatic glands late, and seldom produces metastases, the duration of life, even without operation, often being several years. In one particular variety of epithelioma known as **rodent ulcer**, or **Jacob's ulcer**, the disease progresses very slowly, lasting for ten, fifteen, or twenty years, during which time its growth may be arrested at one edge. Attempts at cicatrization are also seen. It is often difficult to prove the epitheliomatous nature of this disease, although epithelial pearls can generally be found by a sufficiently thorough search,

FIG. 82.



I. Epithelioma of the hand: *a*, slough covering ulcerating area; *b*, epithelial pearl, more highly magnified in II.; *c*, round-cell infiltration of subcutaneous tissue; *d*, normal skin. ×100. (F. C. Wood, M.D.)

and the characteristic penetration of the basement membrane by the cells is usually well marked.

Tubular Carcinoma.—Carcinoma growing from those mucous membranes which have not pavement epithelium contains cylindrical cells arranged like the tubular glands. Tubular carcinoma occurs in the stomach and intestines, being most frequent at points of narrowing like the pylorus and the ileo-cæcal valve, and also in the sigmoid flexure and the rectum. Three-quarters of the cases of cancer of the bowel occur in the rectum, and only about two per cent. of them in the small intestine. Tubular carcinoma is common in the uterus, beginning in the mucous membrane. Cancer of the kidney is always tubular, but this form is rare in the testicle, where the disease is usually encephaloid of the acinous type. Tubu-

lar carcinoma is also found in the skin, originating from the sebaceous and sweat glands, and it is even seen in some of the acinous glands, such as the parotid and the mamma, arising from the small primary branches of the excretory ducts which are lined with columnar epithelium.

Fig. 83.

Epithelioma of foot.

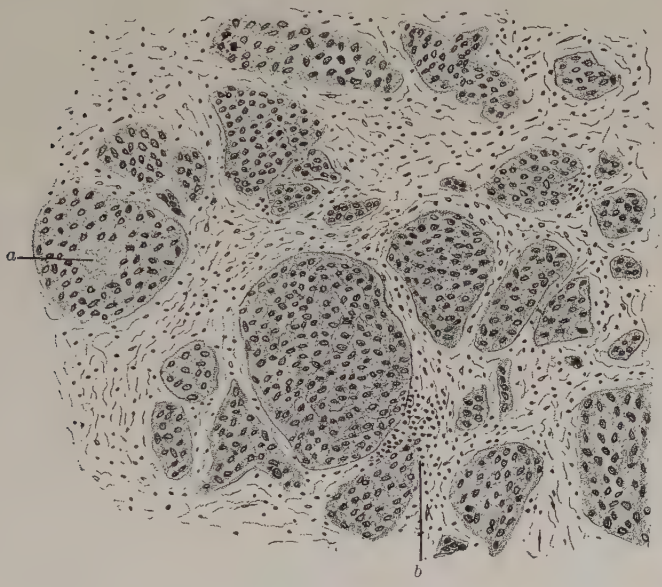
Course.—Tubular carcinoma may grow rapidly and form large tumors, but in the intestine it makes small tumors and tends to produce strictures, owing to the contraction of the fibrous tissue of the stroma of the neoplasm, analogous to the shrinkage found in the atrophic form of scirrhus of the breast. Where this takes place the mucous membrane will be found thickened and the calibre of the intestine is very much narrowed, but when viewed externally the bowel shows no tumor, and looks as if a string had been tied about it at that point, the hard nodules being evident only when the gut is pressed between the fingers. The contracting form of tubular carcinoma is rather slow in its growth, affects the glands late, and is not very apt to form metastases; the softer and rapidly growing variety has a much more malignant character. These tumors run a course of about two years from the time when the first symptoms are discovered, unless life be prolonged by surgical treatment. Metastases from cancer of the stomach and intestine occur most frequently in the liver, and next in the lungs, but they have also been found in the brain and in the bones.

Acinous Carcinoma.—The acinous glands give rise to carcinomatous growths with cuboidal or many-sided epithelium lying in a stroma which more or less closely imitates the gland from which they spring. This variety occurs in the breast (Fig. 84), in the thyroid and salivary glands, and in the pancreas, the ovary, the testicle, and the prostate.

Varieties.—The proportion of the epithelial cells to the fibrous tissue is very variable. In some cases the tumors are very soft, with a scarcely visible stroma, while in others the latter forms the important part of the tumor, and only isolated groups of epithelial cells are found. (Fig. 85.) The first variety is **encephaloid** cancer, which grows rapidly, makes large tumors, ulcerates, infects the lymphatics and forms metastases early, and has a short clinical course. If the fibrous tissue is well developed, we have the **scirrhus** (Fig. 86), which, although equally malignant, is less rapid in its progress. When the fibrous stroma is very abundant and the number of cells is very small, the so-called **atrophic scirrhus** is produced. In atrophic scirrhus the fibrous tissue of the tumor seems to undergo constant contraction, like that seen in scars, and, although the growth extends by the spread of the epithelial cells into the surrounding parts, the contracting stroma apparently interferes with the nutrition of the cells, so that their number is greatly diminished in the older portions. This contraction actually reduces the size of the tumor and of the organ in which it develops, the latter shrinking away, so that the entire breast may become as small as an English walnut, the final result being a fibrous mass containing a few epithelial cells scattered through it, all trace of the gland-tissue being lost.

This variety of tumor grows very slowly, running a course of from six to ten years, with very little tendency to ulceration or hemorrhage, involving

Fig. 84.

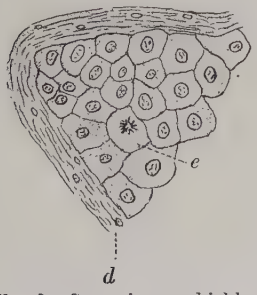


Soft carcinoma of breast, × 150: *a*, broken-down centre of a mass of epithelial cells; *b*, small round-cell infiltration of stroma. (F. C. Wood, M.D.)

the glands very late or sometimes not at all, and forming no metastases. The most common of these varieties of acinous carcinoma is the scirrhus.

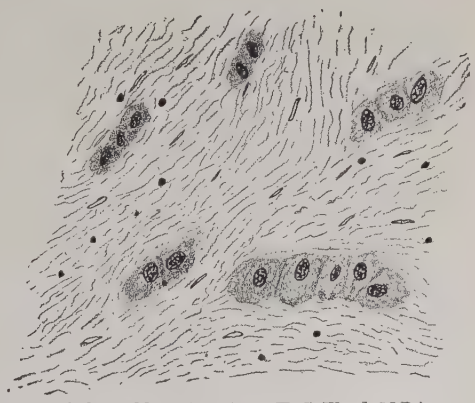
Colloid Carcinoma.—Colloid carcinoma is a rare variety, in which the cells or stroma or both have undergone extensive colloid transformation. The cells are of the cuboidal type, the stroma is toler-

Fig. 85.



Cells of soft carcinoma, highly magnified: *d*, stroma; *e*, cell in active mitosis. (F. C. Wood, M.D.)

Fig. 86.



Scirrhus of breast, × 400. (F. C. Wood, M.D.)

ably abundant, the tumors are hard, not very large, and are prone to cystic degeneration. These tumors are most frequently found in the breast, their course being slow but distinctly malignant.

Symptoms.—The most evident symptom of carcinoma is generally the appearance of a tumor, although it may be very small or not detected, on account of its concealed situation. Pain is present in a certain number of cases, but only, as a rule, when the nerves are directly pressed upon or when the tumor has attained a very considerable size or is growing so rapidly that the parts about it are subject to great pressure. In a very large number of cases of cancer there is no pain, and this fact must be emphasized, because too much reliance has been placed on the existence of pain in making the diagnosis. When the tumor has reached a certain size ulceration usually sets in, and severe hemorrhages may follow. A hemorrhage which occurs directly from the tumor is exceedingly difficult to control unless it yields to pressure, as no ligature will hold in the soft and friable tissue. The nearest lymphatic glands will usually be enlarged, but the time of the beginning and the extent of this enlargement vary greatly in the different varieties of tumors and also in individual cases of the same tumor. The extension of the tumor into the surrounding parts is shown by the adhesion of the skin over its surface or by the fixation of the tumor to the deeper parts, both being due to the direct connection between the stroma and the fibrous tissue about it.

In the later stages of malignant disease a condition of *cachexia* or exhaustion develops, a large part of which is caused by the actual pain of the tumor and the mental anxiety excited by its presence, or by its interference with the functions of some of the important organs. The loss of strength is often dependent upon a large secondary mass in the liver or lung, the presence of which can only be guessed at, as it produces no symptoms except those of slight interference with the functions of the organ. Such secondary tumors, and occasionally the primary growth, interfere with the nutrition of the patient sufficiently to account for the anæmia which is so marked. The yellowish tinge of the skin is frequently due to the presence of a secondary tumor in the liver. It was once supposed that the natural chemical products of these tumors produced a sort of toxæmia, but this view is now held by few, although some support has recently been given to the theory by the discovery that the hæmoglobin of the blood is actually diminished in quantity, even when the tumor is small and the patient is not aware of its existence. It has also been found that when the tumor has been removed and two or three years have passed without recurrence, the proportion of hæmoglobin in the blood still remains below the normal.

Prognosis.—The termination of carcinoma is inevitably death, and this may be expected after one, two, or three years, unless life be prolonged by operation. The ultimate results of these operations vary with the region involved, being best in epithelioma of the skin and of the lips, of which one can hope to cure forty or fifty per cent.; next in cancer of the breast and of the rectum, in which as high as twenty-five per cent. of cures can be obtained in ordinary hospital cases. Operations upon the uterus also give very good results, from twenty-five to fifty per cent. of cures being claimed by some authorities. The results are especially bad in the internal organs, as in the stomach or intestines, because of the difficulty of making an early diagnosis; and also in the tongue, because of the unusually rapid diffusion

of the growth. The results of treatment depend upon the duration of the tumor at the time of operation. In order to obtain a cure the operation must be done, if possible, in the very first stage of the disease, before the lymphatics have been involved. In the breast, cures may be expected in the majority of cases when the glands are not involved, but after the latter are diseased only a very small proportion can be cured. In fact, it is desirable to make the diagnosis of impending malignant disease and to treat it before it fully develops. This may be done in the case of epithelioma of the skin by removing warts which show signs of irritation, patches of seborrhœa which are beginning to ulcerate, or chronic ulcers of the leg which show induration of their edges. The breast should also be removed after the menopause when it is the seat of chronic mastitis and similar conditions. Comparatively small operations under these circumstances will result in the permanent cure or prevention of malignant disease.

Treatment.—The treatment of carcinoma consists in radical removal not only of the original tumor but of all the involved lymphatic glands and, if possible, the intervening parts through which the lymphatic vessels run. The reason is evident from the description already given of the mode of extension of the growth, and the rule holds in spite of the rare instances in which enlarged glands have been left at the time of operation on the original tumor and have been observed to disappear afterwards, or the cases in which the intermediate tissue has been left, the tumor and glands having been removed, and yet no recurrence has taken place. The enlargement of the glands noted in the first-mentioned cases was undoubtedly inflammatory and not true malignant infection, and the success in the second class of cases is to be ascribed to the fact that the lymphatic vessels had escaped contamination although the glands had been involved. The boundaries of the growth of carcinoma are not easy to determine with the naked eye, therefore abundant allowance should be made by removing with the tumor a wide zone of the healthy tissue in its neighborhood. The amount of healthy tissue to be removed will depend upon the size of the tumor and its situation, while a knowledge of the anatomy of the lymphatics and blood-vessels will indicate the direction in which the greater amount of tissue must be removed. In general it may be said that infected or adherent skin must be avoided by at least an inch in the removal of large tumors, and half that distance in the removal of small ones. We may venture to leave a margin of only one-quarter of an inch in minute epitheliomata of the face, where scarring is of importance, but in larger tumors or in other situations not less than half an inch will answer. The fibrous layers of aponeuroses sometimes form a natural barrier to the neoplasm; thus, in the breast, the fascia over the pectoral muscle will often prevent extension inward. In every case, therefore, this fascia should be removed, being treated as if it were the capsule of the tumor, for the muscle underneath is usually sound unless the tumor has become evidently adherent. In the limbs when there is extensive involvement of the soft parts and the glands are clearly infected, amputation should be done, if possible, above the mass of involved glands, as it is not safe to leave the intermediate tissue.

While, as a rule, it is unwise to attempt any operation on tumors which

cannot be completely removed, there are cases in which life can be prolonged or comfort secured by such palliative operations. It is claimed by many surgeons of experience that incomplete operations upon malignant tumors hasten their growth, but the evidence upon which this is founded is not entirely satisfactory, and there is room for the individual judgment of the surgeon as to when he should operate upon cases of this description. A large ulcerating tumor of the breast, for instance, may be removed when there is no hope of a cure, in order to rid the patient of the discomfort of the tumor. Metastatic growths should never be operated upon, except for the same reason, for other secondary growths will probably be found, and there is no hope for a radical cure. This rule, however, should not be held to exclude operations for a tumor of the remaining breast after the other has been removed, because the tumor in the second breast is rarely truly metastatic, and it is to be considered as a primary tumor of another organ.

CYSTS.

A cyst is a tumor containing fluid surrounded by a capsule, either organized or accidental.

Pathology.—Cysts are variously produced. If the duct of a gland or hollow organ be occluded by the growth of a tumor, by cicatricial contraction, or by swelling due to inflammation, the organ may become distended and form a cyst. These are called **retention cysts**, and include hydronephrosis, hydrops of the gall-bladder, sebaceous cysts, mucous cysts, and lacteal cysts. Solid tumors may break down and soften in the centre, their contents becoming fluid, and the remaining part of the tumor being flattened out by the pressure of this fluid until it forms a thin layer, and thus a cyst may be produced. Finally, a true neoplasm of a cystic nature may develop, like the cysts produced in the ovaries, where the cells lining the follicles take on an active growth and the capsule enlarges, keeping pace with the increase of the contents. Cysts of this nature are usually congenital, and are really analogous to the retention cysts, because they represent glandular structures in which the outlet for the natural escape of the secretion has been cut off. Cysts are also formed from old hemorrhages, the clot being absorbed in part and its place being taken by serum which exudes from the sides of the cavity. Cysts may also be produced by dilatation of serous cavities, such as the bursæ.

Sebaceous cysts are found anywhere in the skin where the sebaceous glands exist, and seem to be caused by an obstruction of the duct, although very frequently the latter is free enough to allow the escape of the contents if considerable pressure be put upon them. The cause of this obstruction may be inspissated secretion or a cicatricial contraction about the canal. Sebaceous cysts are most common upon the scalp and upon the back, particularly at the nape of the neck. They vary in size from a pin's head to a man's fist, although they are seldom larger than an egg. They form tense or soft fluctuating tumors, covered by normal skin, which is usually somewhat adherent, particularly in the centre, where the original duct is found. These cysts are very liable to inflammation, and form abscesses, which may

leave a sinus. If the sinus closes, the cyst is liable to form again. The contents of these cysts are the ordinary sebaceous matter secreted by the gland. The wall of the cyst is formed of the fibrous capsule of the distended gland and is lined with flat epithelium, the normal cuboidal epithelium of the sebaceous gland being flattened by pressure.

Treatment.—The treatment of these cysts is excision, and the entire capsule must be removed, or the epithelial cells which line it will reproduce the tumor. When the cyst is not yet adherent to the surrounding parts its removal is easy, a simple incision being made in the skin and the sac being extirpated unopened, but if there are adhesions the removal may be more difficult. In such a case it is well to make two short incisions at the edge of the sac on opposite sides, so as to introduce a blunt instrument and work up towards the apex of the sac, where the adhesions are usually strongest. It will often be possible to enucleate the sac under the skin, and then the skin can be completely divided over the apex of the sac and the latter lifted out. If the sac ruptures it is best to cut entirely through the tumor, dividing the sac into two halves. The contents are wiped out, and the divided edge of the sac at the bottom is seized with a strong pair of forceps and each half twisted out of the wound. This method has the disadvantage of bringing the contents of the sac in contact with the wound, and, although they are not septic unless inflammation has set in, they are apt to hinder primary union.

Mucous Cysts.—Cysts similar in structure to the sebaceous cysts are found on the mucous membranes, the only difference being in their contents and in the mucous character of the epithelium which lines them. They usually have thin walls, and a single application of a strong caustic suffices, as a rule, to obliterate the epithelial lining and effect a cure, although they may also be dissected out. They are most frequently found on the inner surface of the lips. They sometimes become inflamed and burst, and a spontaneous cure may result, but a recurrence is likely to follow. The **ovarian cysts** and cysts formed by dilatation of the **gall-bladder**, of the **kidneys**, or by some obstruction of the ducts in the **mammary gland**, will be described with those organs. The **dermoid** and **branchial cysts** have already been treated of. **Cystic degeneration** is very common in many tumors, but does not alter their course or character, except that their growth is apt to be rather more rapid under these circumstances.

CHAPTER VII.

CONDITIONS AFFECTING THE RESULTS OF OPERATIONS AND INJURIES.

OPERATIONS IN GENERAL.

The propriety of operation in many cases which come under the care of the surgeon is very clear; in others, however, there often arises the question whether the patient is in condition for operation, or whether his expectation of life would be increased by the procedure: it is in such cases that the surgeon has the opportunity to exercise that very desirable attribute, surgical judgment, which is much more essential to his success and the welfare of his patient than mere operative skill. In considering the question of operation the patient and his friends are apt to turn to the surgeon for an opinion as to the possible risks of the procedure and the results to be gained by it; the patient, in our opinion, is entitled to the fullest information upon these subjects. The surgeon should not be an alarmist and unduly excite the fears of the patient, nor, on the other hand, should he treat lightly the dangers of the operation. Timid and nervous patients often require the fullest amount of encouragement that the surgeon can give them. We cannot understand how a surgeon can speak lightly to a patient of serious operations which he knows are often, even when most carefully and skilfully performed, attended with a definite amount of risk to life. We have heard a surgeon tell a patient who was considering the question of having an abdominal section performed that there was no more risk in the operation than in cutting the finger-nails, an opinion in which those who have had experience in this operation could scarcely agree. This making light of the dangers of operations by surgeons is not, we think, due to any want of knowledge upon the subject, but rather to a desire to keep up the courage of the patient.

The surgeon and his assistants should remember that the patient and his friends do not view an operation in the same light as they do, and although it may seem a matter of every-day occurrence to them, it is to the patient an event which is looked upon with the deepest anxiety and even terror. They should, therefore, avoid any excitement, and should proceed with their several duties in a quiet and dignified manner. The surgeon should, as far as possible, make up his mind as to the plan of operation and its various details before it is undertaken, and should endeavor to follow this plan unless unforeseen difficulties arise during its performance. He should not be led from this plan by the gratuitous advice of lookers-on, and should request a consultation only if he feels that those present are competent to help him should unforeseen difficulties arise during the course of the operation. A

vacillating surgeon does not secure the confidence of the patient or his friends. The development of unexpected complications during an operation should not cause the surgeon to lose his head, for should he do so the assistants are also apt to become demoralized, and the safety of the patient is thereby much endangered; indeed, we know of no attribute of the surgeon which is worthy of greater admiration than that steadfastness which in the face of great and unexpected danger during operations enables him to act with coolness and judgment.

The surgeon is often placed in a perplexing position in regard to the consent of the patient in operations of urgency, such as primary amputations, herniotomy, tracheotomy, operations which must necessarily be performed promptly to save life. No surgeon should undertake such an operation upon a patient who is in his right mind and refuses to give his consent to its performance. In children or minors it is unwise to operate without the consent of the parents or guardians. Fortunately, in private practice this complication is not apt to arise, as the parents or guardians are usually present, but frequently children are injured at a distance from their homes and brought to hospitals; in such cases, where immediate operation is required as a life-saving measure, if efforts to find the parents are unsuccessful, the surgeon should perform the operation and place himself *in loco parentis*, fortifying his position, if possible, by a consultation with his colleagues. In the case of an intoxicated person who requires operation, and whom it is impossible to make understand what is to be done, or who refuses his consent to its performance, it is well, if possible, to wait until the patient regains his senses; but if this is impossible, the consent of near relatives may be obtained, or if this cannot be done, and the operation is urgently demanded, the surgeon must assume the responsibility of the operation. In the case of an insane or unconscious person the case should be decided upon the same grounds.

Rest and Diet after Operations.—The surgeon should give explicit directions as regards the management of the patient after serious injuries or operations. A patient who has undergone a serious operation or received a severe injury should be kept at rest in bed with the best hygienic surroundings, and should not be subjected to any excitement; his diet should be simple, and for a few days, at least, should consist of milk and broths; the former is to be preferred if it can be taken; the addition of a little lime water to the milk is often an advantage if there is an irritable condition of the stomach. After a few days, if the patient craves solid food, he may be given a more liberal diet, but it should consist of plain, easily digested, and nutritious food.

Causes of Death after Operations.—The consideration of the causes of death after operations must always be a matter of the greatest interest to the practical surgeon. Every surgeon appreciates the fact that a certain number of patients die after operations from causes directly or indirectly traceable to the operation. These deaths do not always occur in the weak and exhausted only, but also in those who before operation were considered most favorable subjects, nor is the fatal termination in many of these cases in any way due to a lack of skill in the operator. The principal

causes of death after operations are shock, hemorrhage, and wound complications.

Shock.—Shock is a condition of physical depression which may cause the death of a patient before the operation is completed or after its completion. It is a well-recognized fact that shock after certain operations is much greater than that following others; for instance, shock in amputation of the hip-joint is greater than that following amputation of the forearm. Although the introduction of aseptic methods has markedly diminished the mortality following operations, it has in no way affected that following shock; in fact, antiseptic precautions often add to the shock by prolonging the operation.

Secondary Shock.—Secondary shock should also be mentioned as the cause of death following operations. It is a condition which may develop in a few hours or several days after the operation, and is probably due to intense septic infection and the formation of heart-clot, which may be the direct cause of death or may lead to a fatal issue by embolism.

Hemorrhage.—Death may result from hemorrhage at the time of operation, therefore it is important that as little blood as possible be lost during the operation. The use of hæmostatic forceps and Esmarch's bandage has led to a great saving of blood during operations. The rapidity of the loss of blood is also an element of danger during operations; the loss of the same amount of blood, if it escapes gradually, is attended with less danger, from the fact that it is made up by drawing on the serum and blood-cells in the deeper organs of the body.

Intermediary Hemorrhage.—Intermediary hemorrhage, or the bleeding which occurs a few hours after the operation, when reaction has occurred, is another source of danger; it is apt to be more marked if shock has been well developed, as many of the smaller vessels during the depressed condition of the circulation do not bleed, and thus escape the surgeon's observation, and are not ligated.

Secondary Hemorrhage.—Secondary hemorrhage, which may occur at any time from the period of reaction until the wound is permanently healed, was formerly, when the importance of asepsis was not appreciated, one of the chief sources of danger after an operation involving the larger blood-vessels; but, fortunately, at the present time, owing to the very general adoption of the aseptic method of wound treatment, it is rarely seen.

Inflammatory fever and **profuse suppuration** may cause death after operations, but these complications, as well as erysipelas, pyæmia, hospital gangrene, cellulitis, and tetanus, are now much less common than formerly. A condition described as **surgical scarlet fever** is sometimes observed as a complication of operations and injuries. This condition is characterized by a general erythema of the skin, which closely resembles the eruption of scarlet fever. It develops within a few days after operations and injuries, and presents a marked resemblance to scarlet fever, although throat symptoms are usually absent. The condition has been variously attributed to vaso-motor irritation, to general septic infection, and to the toxic action of certain drugs, such as iodoform, carbolic acid, and corrosive sublimate. The

eruption usually disappears in a few days, and does not, as a rule, affect the prognosis unfavorably, except in cases where it is due to a general septic infection.

CIRCUMSTANCES AFFECTING RESULTS OF OPERATIONS.

Various circumstances influence the results of operative procedures. The success of an operation does not always depend upon the skill of the surgeon; the constitutional condition of the patient is often a factor of the first importance in determining the result of an operation. Trivial operations in certain classes of patients are often attended with serious results, and, on the other hand, the gravest operations are sometimes undertaken with little hope of success, yet in these cases the most favorable results occasionally follow. There is an unknown element, the power of constitutional resistance, which even the most experienced surgeon cannot definitely determine. The following conditions should be considered in deciding the question of operation:

Age.—In many operations where the surgeon is called upon to operate to save life the question of age cannot be considered. No judicious surgeon would hesitate to operate upon a strangulated hernia or remove a crushed limb in an infant or an aged person who was in condition for operation, whereas he would probably refuse to perform an extensive plastic operation in an infant for the relief of a congenital deformity, or to remove a deep-seated benign tumor from the neck of an aged person whose expectation of life at best is very short.

Infants and aged persons do not bear operations as well as children and those in middle life; the results of operative procedures in children after the period of infancy are usually very satisfactory, the successful results in this class of patients probably being largely due to the fact that, as a rule, they are not in any degree affected by anxiety as to the operation, that their organs are in a healthy and vigorous condition, that they bear confinement to bed well, and that the nutritive activity of the tissues is in its best condition, so that wounds heal promptly. Infants and young children, however, suffer inordinately from shock, which, if prolonged, may produce a condition of collapse, and they possess a remarkably excitable condition of the nervous system, which is apt to develop a high temperature or nervous symptoms under slight provocation. They also manifest the constitutional symptoms from the loss of blood more rapidly than do adults, but if reaction occurs they recuperate very rapidly. Aged persons are not as good subjects for operative procedures as those in middle life; they are likely to be affected with visceral disease, bear the shock and loss of blood badly, and are apt to become bedridden, so that they should be got out of bed as soon as possible. Age is not a true test of the ability of the individual to bear operative procedures, but rather the vitality of the tissues, and in this connection the saying "that a man is as old as his blood-vessels" is a very true one. We have seen a patient fifty years of age who presented evidence of vascular degeneration which would have been unusual in a man of eighty years. The mere question of years in such a case would be misleading. Aged persons who have sustained injuries of the lower extremities or of the

trunk, which involve long confinement in the recumbent posture, are apt to suffer from congestion of the lungs and from bed-sores.

The *constitutional condition* of the patient should also be considered in performing operations.

Feeble patients, who have been reduced to the condition of extreme exhaustion, for instance, by suppuration of one of the larger joints, often bear operations in a remarkable manner. In such cases the patient's system has accommodated itself to the confinement, and the relief from pain and septic intoxication afforded by the removal of the diseased joint or by the amputation of the limb, and the cutting off of the drain upon the system from profuse suppuration, if the patient withstands the shock of the operation, will often be followed by a very prompt recovery and a remarkable improvement in the constitutional condition.

Corpulent Persons.—Corpulent persons after middle life are not good subjects for operation, often presenting a sluggish circulation and a tendency to pulmonary congestion. In such patients confinement in bed is apt to be badly borne; it is difficult to change their position, they are apt to suffer from bed-sores, and the vitality of the wound itself seems to be largely affected by the immense amount of adipose tissue, which is poorly supplied with blood, so that repair is slow and imperfect.

Gout and Chronic Rheumatism.—Persons suffering from gout and chronic rheumatism are not unfavorable subjects for operation, if it is not done during an acute attack of either of these diseases. It should always be remembered that, although the diathesis itself does not affect the result, there may be present cardiac or renal changes which will have some influence upon it.

Alcoholism.—Persons suffering from chronic alcoholism, whose digestive and excretory organs are deranged, whose nervous system is exhausted, and whose power of assimilating food is diminished, are the worst possible subjects for surgical operations. Operations in this class of patients should be undertaken with great caution, and as far as possible should be restricted to those which are urgent and necessary to save life. It is not only in the hard drinkers that the constitutional effects of alcohol may complicate operations unfavorably, but also in the class of patients who use alcohol habitually but never to the point of intoxication. Serious operations in alcoholics are occasionally found to do remarkably well, but at other times wound complications seem especially apt to develop, and the patient, even after he has abstained from alcohol for some weeks, may after an operation or a severe injury suddenly develop an attack of delirium tremens.

Condition of the Urine.—Examination of the urine should be made in all cases where it is possible before subjecting patients to serious operations, as information obtained from this source may result in a modification of the operation.

Diabetes.—Diabetics are generally considered most unfavorable subjects for surgical operations. All authorities are agreed upon the unfavorable course of wounds and the gravity of operations in diabetic patients. Strict asepsis, however, has rendered operations in these subjects more favorable. Although trivial operations upon this class of patients, such as the opening

of abscesses, may be followed by serious results, yet the surgeon cannot refuse to operate in certain urgent cases, but he should always be mindful of the increased danger to the patient from his constitutional condition.

Chronic Nephritis.—No variety of visceral disease affects the results of operations so unfavorably as chronic nephritis, and grave operations should not be undertaken upon patients suffering from this affection unless urgently called for to save life. A patient suffering from nephritis may present a fairly healthy appearance, especially in cases of contracted kidney, where no albumin is detected in the urine. A trifling operation on such a subject may be a most serious and dangerous procedure. The anæsthetic to be employed should be determined by the fact that the patient suffers from nephritis.

Cardiac Disease.—Patients who suffer from valvular disease of the heart do not seem to be especially unfavorable subjects for operation, if the valvular lesion has been compensated for, but those who suffer from a feeble or fatty heart are especially exposed to risk from the shock of the operation. It has been pointed out by Verneuil that cardiac affections may affect the results of operations unfavorably by causing œdema, passive hemorrhages, thrombosis, and embolism. The results of operations upon patients suffering from *aneurism* of the larger arteries do not seem to be particularly unfavorable.

Atheroma of the arteries does not appear to exercise a markedly unfavorable influence upon the results of operations. It was formerly supposed that secondary hemorrhage was more likely to complicate wounds of atheromatous vessels. If rigid asepsis is practised, and large ligatures are employed and not tied too tightly, such vessels heal as promptly as sound ones. Our own experience with amputations of limbs in which atheromatous vessels were present would lead us to believe that secondary hemorrhage is not more likely to occur than in wounds of healthy vessels; the principal risk in amputations in these cases is from sloughing of the flaps.

Diseases of the Liver.—Verneuil has pointed out that affections of the liver exercise a very serious influence upon operations and injuries. Cirrhosis and fatty and amyloid degeneration of the liver should be considered conditions which render the results of surgical operations most unfavorable, and in subjects suffering from these affections only operations of urgency should be undertaken.

Diseases of the Nervous System.—Insane patients usually bear operations extremely well if they are otherwise healthy and do not require restraint; if, however, they suffer from chronic melancholia or dementia, they are apt to be broken down in health, and are then very unfavorable subjects for operation. Persons suffering from diseases of the nervous system, such as ataxia, paralysis, or chorea, or those who have received injuries of the brain or spinal cord, are not good subjects for operative procedures. We have seen a case of amputation of the leg in a patient suffering from chorea in which death resulted from exhaustion following the irritation produced by the constant moving of the stump.

Hæmophilia.—Hæmophilia is a condition which affects the results of operations unfavorably, and should forbid the performance of a surgical

operation except in cases of extreme urgency. Hæmophilia is certainly a very rare affection. Our own experience with this affection has been confined to two or three cases of wounds about the mouth or face, and a case of castration, in which the bleeding was controlled with great difficulty. The surgeon should not refuse to perform an urgent operation in a patient suffering with hæmophilia, for experience shows that severe bleeding is not so apt to follow serious operations as trivial ones.

Leucocythæmia.—This condition affects the results of operations very unfavorably, and operative procedures in patients suffering with this affection should be avoided as far as possible.

Tuberculosis.—The subjects of tuberculosis are not, as a rule, unfavorable ones for operative procedures, and this is especially true in the case of children. It is surprising how rapidly a child who suffers from tuberculous disease of a joint, which has advanced too far for excision, will improve after removal of the diseased joint by amputation. If, however, there is serious visceral disease, tuberculous subjects are not good subjects for operative procedures. Tuberculous patients advanced in years do not bear operations well. Wounds often heal very promptly in tuberculous subjects, but are apt to break down and reopen.

Syphilis.—Syphilis does not appear to affect unfavorably to any marked extent the repair of wounds or the course of operations. The healing of wounds seems to be practically unaffected even in secondary syphilis. In the later stages of the disease, if the wound involves tissues affected by gummatous infiltration, its repair is usually unsatisfactory, and healing may not be accomplished until constitutional treatment has been administered.

Pregnancy.—Operations should, if possible, be avoided during pregnancy. Patients in this condition may as the result of operation abort, which accident adds greatly to the danger of the operation. Operations of necessity, however, have often to be performed upon pregnant women, and often result satisfactorily. We have seen a number of successful abdominal sections during pregnancy without abortion. We have also seen a successful amputation of the femur in a woman advanced in pregnancy, and Keen has had a successful amputation of the hip-joint in a pregnant woman.

Malignant growths sometimes seem to develop slowly during the period of pregnancy, and after gestation again assume active growth, so that in such cases it is wise to postpone operative interference until after childbirth. The growth of cancer of the breast is, however, often very rapid during pregnancy and lactation. Operations should as far as possible be avoided during menstruation and lactation.

The question of operating during the prevalence of *epidemics* should be carefully considered by the surgeon, and, as a rule, unless the case be a most urgent one, operative interference should be postponed until different conditions prevail. Operations should also be avoided if possible during very hot weather, although the ordinary weather of summer cannot be considered unfavorable for operative procedures. This should be particularly observed in the case of young children, as hot weather often gives rise to diarrhœal troubles, which complicate unfavorably the result of an operation. We have seen both children and adults die of heat-stroke or heat-

exhaustion after operations during extremely hot weather. It is possible also that atmospheric conditions, such as dryness, humidity, and electrical disturbances, have some effect upon the results of operations.

SHOCK.

Shock, or collapse, is a condition of physical depression or prostration which generally occurs after severe injuries or operations, and should not be confounded with *syncope*, which is a condition essentially due to anæmia of the brain, and may result from mental perturbation, from pain, from actual loss of blood, or from the derivation of blood from one part of the body to another, as occurs in the syncope following the too rapid removal of a large quantity of fluid from the abdominal cavity. The condition which supervenes upon serious injuries of the head and spine is often confounded with shock; the two conditions may coexist, and it is often difficult to differentiate them in such cases. That shock may be developed independently of mental emotions is evidenced by the fact that it often manifests itself during complete anæsthesia. Shock may develop immediately upon or some time after the reception of the injury. The rapidity of its development is best shown in cases where vigorous subjects meet with serious accidents, such as crushes of the limbs or body, in whom there develop instantaneously pallor and coldness of the skin, feeble respiration, and almost imperceptible pulse. During operations shock may be developed gradually, except when important structures are divided; its manifestation may then be very sudden.

Pathology.—Various theories have been advanced to explain the pathology of the condition which we recognize as shock: it has been attributed to paralysis of the vaso-motor centres, causing dilatation of the abdominal vessels, which become so distended that the amount of blood in other parts of the body is greatly diminished. This would imply that the symptoms presented by excessive hemorrhage and by shock are similar, which is not the case, as we recognize a distinct difference between the symptoms of the two conditions. The view which is now most generally accepted is that shock is due to severe irritation of the peripheral ends of the sensory and sympathetic nerves, producing a state of exhaustion of the medulla and pneumogastric nerves, or a general functional paralysis of the nerve-centres, both spinal and cerebral, which causes arrest or enfeeblement of the cardiac action and disturbed respiratory action.

Death from shock may be immediate and result from cardiac arrest. Post-mortem examination of these cases usually shows the right cavities of the heart and the great venous trunks distended with blood.

Causes.—Every traumatism is probably followed by a certain amount of shock, but it may be so slightly developed as to escape observation, and, as a rule, the degree of shock is proportionate to the severity of the injury received. Yet this rule is not without exception; certain classes of injuries are attended with marked shock, and the part of the body sustaining the injury will have an important influence upon the degree of the development of shock. Contusions of the viscera, wounds of the testicle, contused and

lacerated wounds of the trunk and extremities, if extensive and accompanied by free hemorrhage, are usually followed by marked and often fatal shock. Excessive loss of blood certainly renders the patient more liable to the development of shock. Gunshot wounds causing perforation of important cavities of the body, injuries of the viscera, and shattering of the bones are also well recognized as giving rise to shock in a marked degree.

Burns and scalds if they involve a considerable surface of the body are attended with severe shock, and those who see this class of injuries cannot fail to be impressed with the profoundness of the shock and its very frequent fatal termination.

Symptoms.—A patient suffering from shock presents pallor of the surface, paleness of the lips, dilated pupils, clammy moisture of the skin, muscular debility, occasionally relaxation of the sphincters, frequent, feeble, irregular pulse, subnormal temperature, and feeble, short, sighing respiration; in many cases extreme thirst is a prominent symptom. The senses are often perfectly retained; occasionally there is diminished sensibility, or the patient may be in a drowsy condition and indifferent to surrounding objects. The temperature is always subnormal, and may vary from a point a little below the normal to a point below 90° F. (32° C.). A depression of temperature below 97° F. (36° C.), if it persists for a few hours, usually indicates a grave condition of shock, and reaction may not occur, although it has been observed in cases where the temperature was as low as 90° F. (32° C.). We have seen reaction occur in a case where the temperature remained at 92° F. for a short time.

Reaction from Shock.—When a patient recovers from shock he passes through a stage of reaction which is characterized by a rise of temperature which may reach or pass slightly above the normal; the skin loses its pallor and assumes a natural appearance, becomes warm, and the moisture which covered it disappears; the pulse grows fuller and stronger, the respirations deeper, and the patient is apt to change his position and may fall into a natural sleep. All things being equal, the longer the symptoms of reaction are delayed the graver is the prognosis.

The reaction may be incomplete, and the patient exhibit evidences of cerebral excitement, presenting a dry, hot skin, flushed face and anxious expression, rapid and compressible pulse, hurried respiration, restlessness, jactitation, and delirium of various degrees, a condition which has been described by Travers as *prostration with excitement*. The reaction from shock may also be excessive, the temperature rising much above the normal, and being accompanied with great mental excitement, constituting a condition which is termed *traumatic delirium*. There is a form of reaction from shock in which the temperature rises very suddenly, and may reach a point several degrees above the normal in a short time, and there is no corresponding improvement in the pulse or respiration, the patient becoming gradually comatose; these cases we have always seen terminate fatally in a few hours. Excessive reaction from shock, if it has been delayed, is said by some observers to be due to septic intoxication, and this view is sustained by the fact that excessive reaction is much less frequently seen now than it was before the introduction of the modern methods of wound treatment. No

more distressing or discouraging cases come under the care of the surgeon than those suffering from profound shock. Often in this condition, in spite of the most careful treatment, reaction does not occur, and the surgeon is compelled to see a patient who has met with a serious accident, who was a few hours before in robust health, rapidly die of shock; this is particularly distressing, as he recognizes the fact that if reaction could have been brought about a surgical operation might have restored him to health and usefulness.

Prophylaxis of Shock.—Recognizing the dangers which the condition of shock entails, treatment to prevent its development is worthy of consideration. Unfortunately, many of the worst cases of shock are due to accidents, and here treatment can be directed only to the condition of shock itself, but the surgeon is often able to diminish to some extent the amount of shock following operations by judicious prophylactic treatment. In patients in whom his experience teaches him that shock is apt to be markedly developed, as in children or feeble or aged subjects, or in certain classes of operations, he may give the patient stimulants before the operation, and also see that the surface of the body is not unnecessarily exposed to chilling during the operation, that the operation is not needlessly prolonged, and that as little blood as possible is lost during its performance. The previous administration of an ounce of whiskey and the hypodermic injection of from one-twentieth to one-thirtieth of a grain of sulphate of strychnine, and sometimes the use of a small dose of morphine, in feeble and aged patients, will often be followed by good results. A full dose of quinine given an hour or two before the operation is also said to arrest the development of shock.

Treatment.—The first indication in the treatment of shock is to establish reaction, and, as death from shock is usually due to cardiac arrest, such means should be employed as will stimulate the cardiac action. The patient should be covered with woollen blankets, the head should be kept low, and dry heat should be applied to the surface of the body by means of hot-water bags, hot bottles, or hot bricks; these should be wrapped in towels to prevent them from coming directly in contact with the surface of the patient's body; neglect of this precaution, which is most important if the patient is unconscious, often produces burns which may be followed by extensive sloughing. If the patient can swallow, he should be given small quantities of whiskey or brandy, with thirty-drop doses of aromatic spirit of ammonia, and, as absorption by the stomach is probably very slow in these cases, stimulants should be administered hypodermically: in our judgment, strychnine is the most valuable stimulant that can be employed. From one-twentieth to one-thirtieth of a grain should therefore be injected, and the injection should be repeated every hour or half-hour until several doses have been given. Sulphuric ether, thirty minims, may also be injected into the cellular tissue at intervals, as well as digitalin or tincture of digitalis.

If shock develops during an operation under ether anæsthesia, the use of ether hypodermically is contra-indicated. A stimulating enema of whiskey and warm water may be employed. In cases of shock where there is profuse sweating, the use of one-sixtieth of a grain of atropine, repeated as

required, is often followed by good results. A large enema of warm saline solution has also been employed with apparently good results. As patients often complain of urgent thirst, it is well to let them take a little black coffee, but not large quantities of water; free indulgence in water does not seem to quench the thirst, and is apt to be followed by vomiting. Transfusion of blood or saline solution has been recommended in the treatment of shock, but has not proved of value, and is likely to be of service only when the condition has been preceded by the loss of a large quantity of blood.

The surgeon should treat the condition actively, and should not be discouraged if reaction is slow, for reaction and subsequent recovery have often occurred in apparently hopeless cases.

The question of *operation* during shock often confronts the surgeon, and we think it is generally conceded that when an operation is not immediately necessary to save life it is better to postpone its performance until after reaction has occurred. Modern methods of wound treatment, although they have in no way diminished the development of shock, allow us to wait for reaction without increasing the danger to the patient from infection of the wound; in such cases the region of the wound and the wound itself should be thoroughly disinfected, and an antiseptic or aseptic dressing should be applied. The cases in which this question is to be considered are usually those of crushes of the extremities requiring amputation, or gunshot or stab wounds of the abdomen; in the former cases it is better to control hemorrhage and direct attention to bringing about reaction from the condition of shock. In cases where it is impossible to control the bleeding or where the means of controlling the bleeding cause the patient great pain, and his temperature is not below 97° F., it may be justifiable to administer ether, and if the patient's condition improves under its employment, the amputation may be performed, often with success. In gunshot or stab wounds of the abdomen, even if the patient presents marked symptoms of shock and exhibits signs of internal hemorrhage, this condition should not deter the surgeon from opening the belly to close visceral wounds or control hemorrhage, for if operative treatment is not instituted death is almost certain.

Secondary Shock.—This condition of shock may develop after reaction from shock is complete, or after operations in which primary shock was not marked. The history of secondary shock is usually as follows: a patient who has reacted from shock, and is doing well twenty-four or thirty-six hours afterwards, suddenly again develops marked symptoms of shock. It is at the present time rarely seen, but is mentioned by the older writers as a frequent cause of death after operations and injuries. It is characterized by the usual symptoms of shock, and is a very fatal complication of injuries or operations. The pathology of this condition is explained by the formation of heart-clots, which embarrass the action of the heart or indirectly lead to the occurrence of embolism. Modern writers incline to the view that it is caused by intense septic intoxication, due to infective changes taking place in the wound. The latter view would seem to be sustained by the fact that secondary shock is very rarely seen as a

complication of wounds or operations at the present time, when rigid aseptic methods are adopted. It is well for the surgeon to bear in mind the possibility of the development of secondary shock after serious operations and injuries, and to guard against its occurrence as far as possible. The administration of carbonate of ammonium in five-grain doses, or of thirty-drop doses of aromatic spirit of ammonia, every two hours for the first twenty-four hours, and then at less frequent intervals, is strongly recommended by Ashhurst, and we have employed it with advantage.

TRAUMATIC DELIRIUM.

This affection may follow injuries or operations, and may be developed after the reaction from shock has been well established. Hunt holds that it is due to anæmia or functional disturbance of the cortical gray matter of the brain, or to inflammation of the cortex or meninges. It may be developed after severe operations or injuries, or after excessive hemorrhage, and severe pain itself accompanying an injury may give rise to this condition of mental aberration.

Symptoms.—The symptoms of traumatic delirium usually appear from twenty-four to forty-eight hours after the reception of the injury ; the patient develops a slight elevation of temperature, acceleration of the pulse, constant muscular action, sleeplessness, and wandering delirium, and usually becomes very loquacious, talking incessantly upon many subjects, but constantly recurring to those which occupied his mind immediately before the injury. We have seen a school-boy, who had received on his way from school a compound fracture of the skull and of the bones of the leg, develop in a few hours an incessant chattering delirium, repeating the multiplication-table for thirty-six hours, apparently without a minute's intermission. In addition to the delirium, patients often seem bent upon removing their dressings, and will attempt to move fractured members unless carefully watched. In hospital practice, where the majority of the patients are addicted to the use of alcohol, it is sometimes a matter of difficulty to say whether the case is one of traumatic delirium or delirium tremens. In delirium tremens tremulousness of the hands and lips is a marked symptom ; in traumatic delirium this symptom is not observed. Death may result from traumatic delirium, and the fatal termination of these cases seems to be due to exhaustion.

Treatment.—In the treatment of this affection it must be borne in mind that the condition is one of exhaustion, and stimulants are generally indicated. The patient should be kept, if possible, in a room free from any excitement or noise, an ice-bag should be applied to the head, concentrated nourishment should be administered at regular intervals, and the administration of whiskey should be guided by the condition of the pulse. The drug which seems to be followed by the best effects in this condition is opium ; this should be administered freely. If, however, this is not used, a combination of chloral hydrate, five grains, and bromide of potassium, ten grains, given every two or three hours, will often quiet the patient and produce sleep. After a few hours' quiet sleep has been obtained, when the patient awakes he is usually free from delirium.

TRAUMATIC FEVER.

In the repair of wounds after operations or injuries there is usually present a certain amount of constitutional disturbance, depending upon the processes taking place in the wound. If the wound remains aseptic the disturbance is slight; if, however, suppuration or specific infection occurs, the constitutional disturbance becomes very marked.

We now recognize two forms of fever which may be developed during the repair of wounds—aseptic fever, and traumatic or inflammatory fever.

Aseptic Fever.—Many aseptic wounds may heal with scarcely any febrile disturbance, but it is not unusual in such wounds to have the patient develop within twenty-four hours a slight elevation of temperature, 100° to 102° F. (37.5° to 39.4° C.), which in a few days returns to the normal. A similar rise of temperature is occasionally observed for a few days after simple fractures. The rise of temperature in these cases is accounted for by the absorption of minute portions of tissue, blood-clot, and effused serum, the so-called fibrin fever. The patient usually presents no disturbance other than the slight fever, and complains of no ill feeling, and the condition requires no special treatment, but the surgeon must beware of attributing every rise of temperature to this cause, for in the great majority of cases the fever is to be charged to slight infection.

Traumatic or Inflammatory Fever.—In the repair of wounds which are not aseptic there will always be observed more or less constitutional disturbance. Before the introduction of antiseptic or aseptic methods in wound treatment it was usual to have this condition develop in all cases of open wounds, and its presence was considered an essential element in wound repair. Traumatic fever usually runs the following course. The temperature rises soon after the infliction of the wound, and at the end of twenty-four or forty-eight hours reaches 103° F. (39.5° C.) or 104° F. (40° C.), with a slight morning remission; it may remain about this point for a few days, and then gradually fall to the normal. Coincidently with the rise in temperature the patient exhibits constitutional symptoms, such as dryness of the skin, loss of appetite, acceleration of the pulse, and diminution of the excretions; the edges of the wound become red and swollen, and more or less purulent discharge escapes from it. The constitutional disturbance arises from the absorption of septic products due to the growth of pyogenic bacteria in the wound. If the discharges have free exit, as soon as the wound is covered with granulations the further absorption of septic products is arrested, the temperature falls, and the evidences of constitutional disturbance gradually subside. If, however, there is free suppuration and drainage of the wound is imperfect, the pus may burrow through the tissues, the temperature continues elevated, and the constitutional disturbance is still marked.

Treatment.—A patient who presents well-marked traumatic fever should be kept at rest, and should be allowed a nutritious and easily digested diet, milk, broth, and semi-solids; a milk diet is the best if it can be taken. A saline laxative is often employed with good results, and the

administration of a diuretic and diaphoretic fever mixture will often render the patient's condition much more comfortable. The wound should also be inspected, and if pus is present and cannot escape, free drainage should be provided by removing sutures and introducing a drainage-tube, or by making counter-openings if necessary. In such an inflamed condition of the wound moist dressings will often be more comfortable than dry ones, and will facilitate the escape of pus.

DELIRIUM TREMENS.

This is an affection of the nervous system characterized by disturbed mental condition, tremor of the muscles, and delirium, which not infrequently comes on after operations and injuries in persons who are addicted to the habitual and excessive use of alcohol. It may follow an injury received while the patient is on a debauch, or may develop upon the reception of an injury some weeks after the patient has entirely abstained from the use of alcohol. Patients usually recover from an attack of delirium tremens, but occasionally death results from this affection, and post-mortem examinations show congestion and serous exudation of the membranes of the brain and ventricles.

Symptoms.—The development of this affection following an injury is usually rather rapid ; the patient is restless, and marked tremor of the muscles is observed ; he is disinclined to take food, and does not sleep. When the disease is fully developed, the muscular tremor is increased, there is absolute insomnia, the patient is extremely restless, attempts to remove his dressings and to get out of bed, is delirious, and is often the subject of delusions. He imagines persons or objects are present to do him an injury, and attempts by persuasion or threats to deter them from their purpose. When the delusional stage of the affection is well developed, the patient is often in an excited state, both mentally and physically. The temperature is usually elevated, but seldom reaches 103° F. (39.5° C.).

Treatment.—When the surgeon observes that the patient is threatened with an attack of delirium tremens he can often ward off the development of further symptoms by the use of sedatives : bromide of potassium and chloral in full doses should be administered, and the patient should be given nourishment in a concentrated form : if under this treatment he obtains sleep, the symptoms usually disappear rapidly. When the affection is fully developed, it is often necessary to restrain the patient in bed by securing the arms, legs, and body by bands made from sheets, care being taken that they are so applied that he cannot injure the parts included in the bands by his uncontrollable movements. It is a matter of the greatest importance to secure sleep for the patient : hence bromide of potassium and chloral should be freely administered. He should be given at the same time concentrated nourishment, milk, and beef tea, and the addition of a little tincture of capsicum or Cayenne pepper to the latter will often be found of advantage. If the restlessness does not subside and the patient is not able to retain nourishment and there is evidence of cardiac failure, it may be necessary to administer whiskey, aromatic spirit of ammonia, or strychnine ; it is, how-

ever, not often that alcohol has to be resorted to in these cases. In some cases in which quiet cannot be obtained by these means, a blister applied to the nape of the neck will be followed by marked amelioration of the symptoms. If under the treatment of sedatives and nourishing food sleep is obtained, the nervous symptoms usually disappear rapidly and convalescence is soon established. We have seen patients who developed delirium tremens after injuries, the acute symptoms having subsided, and who were taking nourishment fairly, develop a condition of mental disturbance, characterized by mild delirium, hallucinations, insomnia, restlessness, and tendency to get out of bed, this condition being always more marked at night than during the day; this affection we have seen persist for some weeks and finally end in recovery. The treatment which we have found most satisfactory is the administration of one-twentieth of a grain of nitrate of strychnine three times a day and a full dose of bromide of potassium and chloral at night.

FAT EMBOLISM.

This is an affection which has recently attracted much attention, occurring as a complication of injuries and inflammatory conditions of the bones, and after contusions of parts rich in adipose tissue. Fat is present in the urine after fractures of the bones, either simple or compound, in two forms, as fluid fat and as an emulsion. Scriba demonstrated the presence of fat in the urine from two to four days after the injury in eighty per cent. of cases of bone injury, including simple and compound fractures, operations upon bone, and inflammatory condition of the bones; he found it present in ninety per cent. of fractures alone. Halm found it present in twenty-eight per cent. and Riedel in forty-two per cent. of the cases examined, but both of these observers failed to recognize the emulsified form, which is the more common. Boyd and Horsley, in a similar investigation, found its presence in the urine exceptional.

The affection known as fat embolism results from the absorption of fluid fat or oil-globules from the crushed cancellated structures and marrow of the bones, or from other adipose tissue, which enters the circulation and is carried to the heart, and then to the pulmonary capillaries, giving rise to embolism of these vessels; the fat may also reach the capillaries of the brain and spinal cord. In the majority of cases the fat is probably disposed of in the liver and kidneys.

Symptoms.—The affection usually develops suddenly from forty-eight to seventy-two hours after the injury, but may occur at a much later period. It is characterized in mild cases by restlessness, slight dyspnœa, and increased rapidity of the pulse; these symptoms may last for a few hours and gradually subside. In more severe cases there are developed marked dyspnœa, œdema of the lungs, frothy and bloody expectoration, cyanosis, delirium, and coma, usually leading to a fatal termination.

Treatment.—The treatment of fat embolism complicating fractures, when actually developed, consists in the administration of digitalis and strychnine to sustain the action of the heart; digitalis is especially indicated

in these cases for its action upon the kidneys. In the severer cases, unfortunately, little can be done by treatment: the symptoms develop with great rapidity, and the patient usually dies in a few hours. Cupping of the chest has been recommended, and alcohol, digitalis, and strychnine should be administered. Many surgeons whose experience with fractures has been very extensive have never seen a case of fat embolism. We have personally seen two cases of fat embolism following simple fractures which resulted in death. One of the cases was a boy eight years of age, who by a fall sustained simple fractures of the bones of both thighs and of both arms, and a compound fracture of the upper jaw: he did well for ten days, when he suddenly developed urgent dyspnœa, frothy and bloody expectoration, delirium, and coma, and died in a few hours; the other case occurred in a simple fracture of the femur.

HÆMOPHILIA.

Hæmophilia, or the hemorrhagic diathesis, is a congenital, constitutional condition in which the subjects are liable to severe and obstinate hemorrhage, which may be spontaneous or follow injuries, often very slight ones. The condition is usually hereditary, and is apt to affect males rather than females, although it may be transmitted by females to their offspring. The subjects of this condition are commonly known as "bleeders." These patients often lose a large amount of blood, and present marked constitutional signs of excessive hemorrhage, but usually recover very rapidly when the bleeding is arrested.

The pathology of hæmophilia has never been satisfactorily explained. It has been stated that the walls of the arteries in this condition are abnormally thin, especially the intima. No other evidence of abnormality in the vascular system has been observed.

A patient possessing this constitutional condition will often, upon the reception of a slight wound, such as a scratch, or an incision of the skin, or the extraction of a tooth, suffer from a continuous and profuse hemorrhage which may prove fatal. Contusions may be followed by extensive subcutaneous hemorrhage. A spontaneous hemorrhage may occur from the mucous membrane or from the serous surface of the synovial membrane of the joints. The diathesis usually manifests itself at the beginning of the first dentition or at puberty, and there has been noted in these cases a tendency to swollen and painful joints and muscular pains often mistaken for rheumatism. The condition is certainly not common, or more cases would be observed by surgeons in their extensive hospital work. The few cases we have observed have occurred in wounds of the lips and mouth, and these ended in recovery.

Treatment.—In cases of spontaneous hemorrhage the patient should be kept at rest in the recumbent posture, and should be given acetate of lead and ergot in full doses. In traumatic hemorrhage, if a cavity exists, it should be firmly plugged with iodoform gauze, or the actual cautery may be applied, or, if the bleeding be from an incision, a compress should be firmly applied, and at the same time the patient should be given constitutional

treatment. Transfusion of blood has been practised in these cases, but apparently has been of little service, and the wound made in its performance subjects the patient to the risk of additional bleeding.

INSANITY AFTER OPERATIONS OR INJURIES.

A form of insanity described as *confusional insanity* is occasionally observed as a complication of operations and injuries. It has been attributed to the shock of the operation or injury, or to the nervous tension or anxiety preceding the operation, or to the use of an anæsthetic. It has been most often observed after injuries of the head, as would be expected, but is a rare sequela of surgical operations; it is apt to occur when there is a complete absence of heredity, and in persons free from any neurotic taint. When the affection develops after an injury or operation there is usually a period of quiescence of from three to eight days, but it has been observed as late as eight weeks after an operation. When it occurs after the employment of an anæsthetic it is developed directly after its use. Its occurrence has also been attributed to the toxic action of certain drugs, such as carbolic acid or iodoform employed in the dressing of wounds: we have seen a case develop after iodoform poisoning in an elderly man.

That it may occur independently of the use of anæsthetics or drugs is proved by its occurrence in cases of injury where no anæsthetic was employed, and in patients in whom the aseptic method only was employed.

We have seen the affection develop after the operation of nephrectomy and after a fracture of the femur, as well as after injuries of and operations upon the brain. In the majority of cases, if the affection is moderately acute, complete recovery follows.

A slight cerebral disturbance is seen in elderly persons after injuries or operations, especially marked at night. This can often be avoided by having them sit up for a part of the day and by giving a milk punch at bedtime.

TRAUMATIC HYSTERIA OR NEURASTHENIA.

This is a condition which is sometimes observed after a severe physical shock combined with a mental shock. The subjects of this affection are usually those who have been in railway accidents, but it is also observed after other accidents. (See Railway Spine.) The affection is rarely developed after surgical operations. It is said to occur most frequently in middle life, and is observed both in males and in females.

Symptoms.—Patients often complain of uneasiness, headache, pain in certain portions of the body, relaxation of the sphincters, disturbance of vision and of the sexual organs, incontinence of urine, paralysis, hyperæsthesia, and anæsthesia. Direct injury of nerve-trunks seems to predispose to the development of this condition, and a neurotic temperament also favors it. The exciting cause of the condition is usually an injury, and the gravity of the injury seems to bear no direct relation to its development, rather being dependent upon the terror and shocking surroundings at the time of the accident.

Treatment.—Under favorable circumstances, if the patient's mind can

be diverted from his condition and the element of expectancy eliminated from the case if it be one in which compensation is sought for by settlement of the claim, recovery will take place. Isolation of the patient from sympathizing friends, the use of tonics and massage, with faradism, and a form of rest treatment such as is recommended by Weir Mitchell, will often be followed by complete recovery.

GANGRENE.

Gangrene and mortification are terms employed to indicate the death of the soft tissues in greater or smaller masses. The term sloughing is also used as synonymous with gangrene, and the dead tissue is known as a *slough* or *sphacelus*. Gangrene results from specific infection of the tissues, from an insufficient supply of nourishment to them, or from their mechanical destruction, and the condition may be brought about in different ways. It may result from the stasis and exudation consequent upon inflammation, the blood-vessels themselves being so compressed that their vitality is destroyed. It may also result from the sudden or gradual occlusion of the main arteries or veins of a part, or from mechanical injuries to the tissues, as seen in extensive crushing or laceration, mechanical strangulation, or the devitalization of parts by heat or cold. Localized gangrene following injuries of the cerebro-spinal axis is sometimes observed: here the predisposing cause of the affection is probably a disturbance of the vaso-motor equilibrium.

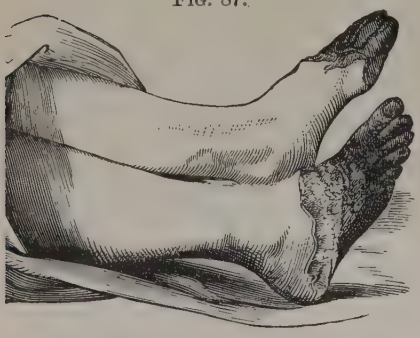
In both *dry* and *moist* gangrene, when the gangrenous process is arrested, the dead tissue is separated from the living by a process of inflammation; the living tissue at its point of contact with the dead tissue and for some distance from it becomes red and swollen, and exhibits all the signs of acute inflammation; the line of contact between the dead and the living tissue is known as the line of *demarcation*, and the line of granulations which separates the dead tissue from the living is known as the line of *separation*. The separation of the dead tissue is effected by granulations which spring up from the living tissue as the result of inflammation, and there is also a certain amount of pus secreted from the granulations. In moist gangrene the lines of demarcation and separation are most fully developed; in dry gangrene, on the other hand, these lines are usually imperfectly developed.

For practical purposes the varieties of gangrene may be considered as follows: *dry* gangrene, *moist* gangrene (which is divided into *localized traumatic* gangrene and *traumatic spreading* gangrene), gangrene from *bed-sore*, *hospital* gangrene, *white* gangrene, *symmetrical* gangrene, and *diabetic* gangrene.

Dry Gangrene.—This variety of gangrene, also termed *senile* gangrene, occurs especially in old persons, and is rarely seen in subjects under fifty years of age, although, if favoring conditions are present, typical dry gangrene may occur in the young, as evidenced by its occurrence in young persons who suffer from chronic ergotism. Dry gangrene essentially results from a gradual diminution of the arterial blood-supply, depending upon a feeble heart, or upon obstruction of the arteries by atheromatous deposits, and sometimes from embolism, the return of venous blood being usually not interfered with in this form of gangrene.

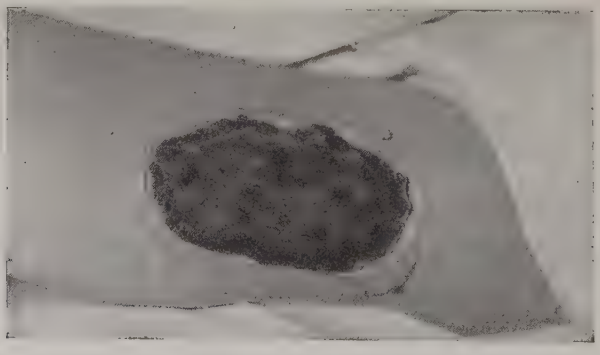
Symptoms.—Typical dry gangrene usually develops in the toes and feet, and the principal symptoms which point to its development are coldness, numbness, pain, and tingling in the feet and muscles of the leg. Persons about to be affected with dry gangrene often complain, for months before any local signs of gangrene are apparent, of severe burning pain in the feet at night when warm in bed. A trivial injury, such as a bruise, the friction of the shoe, or the cutting of a corn, may act as the exciting cause of the affection. The part becomes congested and gradually assumes a dark purple color, finally becoming black and dry (Fig. 87): it is insensitive, but the surrounding parts are congested and may be the seat of intense pain. The dead part becomes black, shrivelled, and dry, and emits little odor. Dry gangrene usually spreads very slowly: one or two toes may first be involved, and the disease may gradually spread to the rest of the foot and the leg. There may be little fever at first, but if a large extent of tissue is involved a certain amount of septic fever develops. During the progress of the disease pain is usually present to a greater or less degree, sometimes being intense; this is accounted for by the fact that the nerves are usually the last structures to die. During the course of the disease the patient loses much sleep from the continued pain, and he becomes worn out and may die of exhaustion. In dry gangrene there is usually no well-marked attempt at the formation of lines of demarcation and separation, but in some cases,

Fig. 87.



Dry gangrene of the feet. (Agnew.)

Fig. 88.



Dry gangrene of skin of thigh from phlebitis. Separation of slough.

if the amount of tissue involved is small, one or two toes or a part of the foot, for instance, and the patient's strength can be sustained, the line of separation forms, and the dead tissue may be cast off, leaving the bones exposed in the wound. In dry gangrene resulting from thrombosis or embolism there is usually a well-marked line of demarcation. (Fig. 88.)

Treatment.—When dry gangrene is actually developed, the part should be disinfected thoroughly and wrapped in dry bichloride, iodoform, or carbolized gauze, or in salicylated or bichloride cotton. Dry dressings such as these permit evaporation of moisture from the tissues and facilitate the drying of the parts. Wet dressings and ointments should not be employed, as they soften the tissues and favor decomposition. The constitutional condition of the patient also requires attention. He should be given a generous diet, with tonics, and care should be taken that a sufficient amount of sleep is obtained. Pain is often a prominent symptom, and should be relieved by the free use of opium; the deodorized tincture of opium is the preparation which we have employed with good results. In some cases codeine, given in doses of half a grain, repeated frequently, acts well. Opium, aside from its action in relieving pain, seems in many cases to have a very considerable effect in arresting the progress of gangrenous diseases, as has been pointed out by Pollock.

The question of **amputation** often requires the gravest consideration in cases of dry gangrene. As this form of gangrene is usually very slow in its progress, if the patient's strength can be sustained, the operation may be deferred until it is evident that the limb is likely to be involved, or until there is an attempt at the formation of a line of demarcation. In embolic gangrene amputation should be postponed, if possible, until this line has formed. At the present time the results following amputation for dry gangrene are more satisfactory, owing to the employment of aseptic and antiseptic methods, and to the fact that amputation is now done at a point far above the diseased tissues, and the operation is therefore much more frequently resorted to.

In a case of dry gangrene, therefore, in which the foot and a portion of the leg are involved, if the patient is not too feeble, amputation should be performed at the knee-joint or in the lower part of the thigh; the latter position is preferred by some surgeons, as the blood-supply of the flaps in this region comes from the profunda femoris.

Moist Gangrene.—Moist gangrene may occur from the direct mechanical destruction of the vitality of the tissues, such as occurs in extensive crushing and laceration of the parts in machinery accidents, or from the passage of heavy bodies and wheels of wagons and cars over the parts. It may also result from the sudden obstruction of the main arterial current, from division or ligature of an artery, or from an embolus, or obstruction of the main veins, as is observed in cases of strangulation of parts by tight bandaging or ligatures. It may result also from obstruction of the blood-supply by the exudations resulting from inflammation, or from the primary or secondary effects of heat and cold, as is seen in burns, scalds, or frost-bite.

Direct Gangrene.—A form of moist gangrene which may be described as *direct* gangrene may result from the immediate crushing of the tissues by an accident, their vitality being instantly destroyed. Examples of this form of death of tissues are common in machinery and railroad accidents and in parts crushed by heavy bodies; here the parts are cold and discolored, and present no signs of putrefaction unless exposed to the air for some time.

It is possible to have traumatic gangrene of the dry type if the tissues are not infected; but if they become infected they soon present the appearances of moist gangrene.

The variety of gangrene which usually results from traumatism causing interference with the return of venous blood, or from sudden obstruction of the arterial blood-supply by injury of the vessels or by an embolus, or from the presence of inflammatory exudations, is known as traumatic gangrene, and may occur in two forms—*localized traumatic* gangrene and *traumatic spreading* gangrene.

Localized Traumatic Gangrene.—This form of moist gangrene may result from crushing or laceration of the tissues, from injuries of the main veins interfering with the return of venous blood, from injury or sudden obstruction of the principal arteries of a part, or from sudden constriction of the vessels by tight bandages or ligatures; it may also develop as the result of burns, scalds, or exposure to extreme cold. Venous obstruction plays a very important part in the production of moist gangrene. A certain amount of tissue is often devitalized as the result of the injury, but in addition to this there is a considerable destruction of contiguous tissues as the result of inflammation and septic infection, which diminishes the vascular supply of the parts by compressing the vessels, so that the damaged tissue as well as the surrounding parts becomes gangrenous; the process does not extend indefinitely, but soon becomes localized.

Symptoms.—When a part which has had its vitality seriously interfered with becomes gangrenous, pain which may have been present suddenly ceases, the part becomes insensitive, and the skin is cold, pale, and mottled, purple, green, and red, and finally dark-colored; blebs containing brownish serum form upon the surface; the wound, if one is present, assumes a grayish color; an offensive discharge escapes from it, and the dead tissue rapidly undergoes putrefactive changes. (Fig. 89.) Coincidently with these changes in the dead tissue, the living tissue in contact with it becomes red and swollen, and the separation of the dead tissue from the living is effected by an ulcerative inflammation, granulations from the living tissue lifting off the sloughs. (See page 23.) The patient at the same time, if the gangrenous process involves any considerable extent of surface, exhibits the constitutional signs of inflammation, fever, rapid pulse, and in some cases, if the septic infection is intense, may die from septicæmia.

Fig. 89.

Moist gangrene.

Traumatic spreading gangrene is considered under infective diseases, page 51.

Treatment.—In tissues whose vitality has been impaired by injury the development of moist gangrene may be averted or its extent may be limited by careful sterilization of the wound and the surrounding parts, and by making incisions to secure free drainage and to relieve tension.

In **direct gangrene**, where, as a result of the injury, the part is absolutely dead, as is often seen in injuries of the limbs in railway and machinery accidents, it is manifestly unwise to wait until putrefactive changes have occurred in the dead tissues, for, although it is possible to keep the part from putrefaction for a few days by careful sterilization of the wound and the use of antiseptic dressings, sooner or later these changes will occur, and a certain amount of constitutional infection will take place. In such a case the part should be removed by amputation as soon as the patient has reacted from the shock consequent upon the traumatism, care being taken that the operation is done through tissue the vitality of which has not been impaired by the injury.

In **traumatic gangrene** involving the extremities, as soon as the gangrenous process is well established, if the patient's constitutional condition is fair, it is wise not to wait for lines of demarcation and of separation to form, but to amputate the part through healthy tissue and thus avoid the risk of incurring septic infection.

In **localized traumatic gangrene** where the question of amputation is not to be considered, incisions should be made to relieve tension and to favor the escape of discharges, and the part should be dressed with dry antiseptic dressings. Under this treatment the dead tissue will be thrown off after the line of separation is well established, and a healthy granulating surface will be left.

In gangrene resulting from *burns*, *scalds*, or exposure to *cold*, it is often difficult to ascertain how far the process will involve the tissues, so that it is in these cases wiser to wait until the lines of demarcation and separation are formed before resorting to operation.

As there is often a considerable amount of constitutional disturbance in cases of traumatic gangrene, the patient should be given stimulants and quinine, with opium to relieve pain and secure sleep, and should also have a nourishing diet.

In moist *gangrene* resulting from *embolism*, if amputation is required the operation should be delayed until the line of demarcation is fully established, as in such cases it is usually impossible to determine the limit of the gangrenous process before that time.

Gangrene from Pressure.—Continued pressure upon a part will often result in the production of localized gangrene. This is more apt to result in parts where the circulation is feeble and the conditions are favorable for complete stasis. **Decubitus** or **bed sores** are produced in this manner in debilitated subjects by long rest in one position in the recumbent posture; the parts usually attacked are the skin over the sacrum and that of the scapulæ, and the heels. The same condition may result from the long-continued application of splints; the gangrenous surface in these cases is known as a **splint-sore.**

A form of gangrene known as **neuropathic gangrene** is often observed after fractures of the spine or injuries of the spinal cord; here sloughs form rapidly in the tissues over the sacrum and heels and in other parts subjected to pressure. Gangrene in these cases seems to be due to a functional disturbance of the vaso-motor or trophic nerves. In patients who are to be

kept in one position for a considerable time, or those who wear splints for a long time, the surgeon should bear in mind the possibility of the development of bed-sores or splint-sores.

Treatment.—As a prophylactic measure the parts should be kept dry, and should be occasionally sponged with dilute alcohol and dusted with powdered boric acid. If the skin shows signs of pressure, the part should be protected from pressure by the application of a piece of soap plaster, made by spreading emplastrum saponis upon chamois-skin; or should be relieved from pressure by placing under it soft pads stuffed with hair, or a perforated air-cushion. In injuries of the spine the use of a water-bed will often prevent the development of bed-sores. When bed-sores have actually formed, the separation of the sloughs may be facilitated by the use of moist dressings, such as gauze saturated in acetate of aluminum or carbolic solution. When the sloughs have separated, the resulting ulcer should be dressed with powdered aristol and boric ointment, and care should be taken to keep the parts free from pressure by the use of an air-cushion.

White Gangrene.—This form of gangrene arises from general causes, and is supposed to result from anæmia of a part due to a localized vaso-motor condition. The lower extremities are usually attacked, but it may occur in any part of the body; it is said to occur in early adult life in those in whom nutrition is defective. Pain in the nerve or nerves leading to the part about to be involved is noticed for some time; later a circumscribed white spot forms, often circular in outline, or a toe or a finger may be involved; the skin becomes white and shrivelled, and soon an inflammatory area develops around this spot, forming a line of separation, and the dead tissue separates, leaving a healthy ulcer. If the destruction of tissue is confined to the skin, the affection is not a serious one, but if the deeper tissues are involved, the condition may be dangerous.

Treatment.—The patient should be given tonics and a nutritious diet, and if the gangrenous process is not fully developed the use of the galvanic current may arrest the further progress of the affection. The treatment of the gangrenous parts is that applicable to cases of moist gangrene.

Symmetrical Gangrene (Raynaud's Disease).—This is a rare form of gangrene, which is supposed to result from persistent vaso-constrictor spasm brought about by reflex action. The parts attacked are commonly exposed portions of the body—the fingers, toes, ears, knees, and cheeks. The disease is usually observed in children or young adults. The parts about to be attacked by this form of gangrene are liable to be cold, pale, and numb for some time, presenting a bluish and congested appearance, which is accompanied by burning pain, and later gangrene sets in, generally of the dry form, although moist gangrene has been observed in such cases.

Treatment.—The protection of the parts from cold and the application of the galvanic current have apparently arrested the progress of the disease. When gangrene has actually developed, the treatment is that appropriate for dry or moist gangrene.

A similar form of gangrene, resulting from vaso-motor spasm, caused by the prolonged use of ergot or by the use of bread made from diseased

rye, has been observed. In such cases the extremities are usually involved, and the condition of gangrene is preceded by cramps, coldness and hyperæsthesia of the extremities, and diarrhœa. This form of gangrene is of the dry variety, and if operation is required it should be postponed until the lines of demarcation and separation are formed, as it is impossible before these are formed to estimate the amount of tissue that will be destroyed.

Diabetic Gangrene.—The development of gangrene in diabetics results from the facts that these subjects have thickened vessels, due to the occurrence of endarteritis, and that the tissues in diabetic individuals are feeble and less able to resist injuries and the infection of pyogenic organisms than healthy tissues. Diabetics also may suffer from a form of peripheral neuritis, or enervation of the parts from disturbance of the central nervous system.

Diabetic gangrene may be due directly to the presence of diabetes or may result from trifling injuries because the patient suffers from diabetes. This affection runs a rapid course, is characterized by excessive inflammation, and is of the moist variety. The prognosis in diabetic gangrene is always grave, the patient being in a markedly asthenic condition, and death usually resulting from septicæmia, exhaustion, or diabetic coma.

Treatment.—Formerly operation in cases of diabetic gangrene was not considered justifiable, but at the present time, with the employment of aseptic and antiseptic means, operation in these cases may be undertaken with a fair prospect of success. In this form of gangrene involving the extremities, amputation should be done at some distance above the seat of disease ; the most rigid asepsis should be practised, so that the wound shall not be infected, and if these precautions are observed the disease is not apt to recur in the stump.

The drugs which seem to exert the most favorable influence in diabetic gangrene are opium and codeine ; one or the other of these should be used freely : the patient should be placed upon an anti-diabetic diet, consisting of animal food, eggs, fish, and milk, and should avoid foods containing sugar and starch.

Diabetic patients should be warned of the dangerous consequences which may follow from slight injuries, such as the cutting of corns, abrasions, etc. In the treatment of wounds in diabetics strict asepsis should be the rule.

Gangrene from Acute Fevers.—This form of gangrene is occasionally seen after typhoid fever, and develops during convalescence ; the parts most frequently attacked are the extremities. This affection results from thrombosis or embolism, and is usually unilateral, the gangrene is of the dry variety. We have recently seen a patient who developed during convalescence from typhoid fever a large patch of gangrene upon the anterior surface of the leg. The treatment of this form of gangrene consists in applying dry antiseptic dressings and waiting until the lines of demarcation and separation are formed, and if amputation is required it should be postponed until this time. Gangrene of the cheeks or of the genitals (noma) occurring in the course of measles or scarlet fever is considered in another portion of this work.

SCURVY.

Scurvy is an acquired constitutional affection caused by improper diet and imperfect hygienic surroundings, in which there are marked disturbances of nutrition and hemorrhages into various tissues of the body. It is now generally conceded that a lack of vegetable food with a prolonged diet of salted meats is the most common factor in its development, but the use of impure water and bad hygienic conditions may also play a part in its production.

The change in the physical and chemical composition of the blood gives rise to hemorrhagic extravasations in the skin, mucous membrane, connective tissue, muscles, and viscera. The skin and mucous membranes may be the seat of bleeding or of extensive ulceration.

Symptoms.—The early symptoms of this affection consist in extreme lassitude or debility, with shortness of breath and rapidity of the heart's action upon slight exertion. The skin becomes harsh and dry, the patient complains of muscular pains, the gums are swollen and œdematous and bleed freely, the mucous membrane of the mouth is affected in a similar manner, and the breath has a foul odor; the temperature is not usually elevated. Petechiæ and extravasations of blood occur in the skin, and extravasations of blood may also take place into the connective tissue, the muscles, or the viscera, or beneath the periosteum; or bleeding may occur from the mucous or serous membranes.

The prognosis in cases of scurvy is usually favorable if the diet and surroundings of the patient can be changed.

Treatment.—The prophylactic treatment consists in the use of fresh meats, and such articles of diet as eggs, milk, potatoes, carrots, onions, cabbages, fruits, lemons, and lime-juice, with improvement of the hygienic conditions. When the affection is well developed, the treatment consists in the use of an antiscorbutic diet, such as the above-mentioned, and the administration of nitrate of potassium and the vegetable acids, and, in debilitated cases, the employment of tonics, such as quinine, strychnine, and iron.

If ulcers are present, they should be cleansed, and antiseptic and astringent mouth-washes should be employed to improve the condition of the gums and the mouth.

CHAPTER VIII.

ASEPSIS AND ANTISEPSIS.

THE student or practitioner of to-day who witnesses the behavior of wounds, either accidental or inflicted by the surgeon, which have been subjected to the modern methods of wound treatment, cannot realize the very different course which such wounds pursued before antiseptic and aseptic methods were adopted: those only who saw the results of the old methods of wound treatment can fully appreciate the value of the new. Before the introduction of Lister's method of treating wounds, based upon Pasteur's investigations regarding the action of bacteria in producing fermentation, it was the rule in accidental and operative wounds to have profuse suppuration, fever, pain, and in many cases such wound complications as septicæmia, pyæmia, erysipelas, and hospital gangrene, and it is not remarkable, therefore, that the mortality following operative and accidental wounds was very high. The mortality in compound fractures from sepsis was formerly very great, but by modern methods of wound treatment has been diminished to an insignificant percentage. Dennis records six hundred and eighty-one cases of compound fracture in which one death only was due to sepsis, a death-rate of less than one-sixth of one per cent. The same diminished mortality has been found to follow amputations and other wounds, accidental or operative.

Lister's method of wound treatment was largely based upon the idea that the infection of the wound occurred from contact with the air, which contained spores and germs, and his method of treatment was chiefly directed to their destruction. The air can be a medium of wound infection to a certain extent, for it has been demonstrated that dry air contains dust in which spores and bacteria are present in much larger numbers than in moist air, and such air coming in contact with an open wound deposits there numbers of bacteria, which may set up fermentative changes. Koch later demonstrated the fact that atmospheric microbes were chiefly of an innocuous character, and that wound infection was generally caused by bacteria or spores being brought in direct contact with the wound by the clothing and skin of the patient, the instruments and the hands of the surgeon and assistants, and unclean surgical dressings. It has been pointed out by Cheyne that the relative number of bacteria entering the tissues is an important factor in producing suppuration and septic infection, for we know that bacteria may exist in an aseptic wound and yet the wound heal and remain aseptic, the antiseptic qualities of the blood-serum and the cell-activity in healthy tissues being sufficient to destroy or remove a certain number of micro-organisms, and suppuration or septic infection occurring

only when the tissues are overwhelmed by the number of organisms, or when their power of resistance is diminished by injury or disease. This is probably the explanation of the satisfactory behavior of wounds which pursue an aseptic course where very imperfect details of aseptic or antiseptic treatment have been employed. It may, therefore, be assumed that infection does not necessarily depend upon the presence of a few microbes, but rather upon the quantity and quality of the germs which are present in the wound. For description of special micro-organisms, see Surgical Bacteriology.

It is unquestionable that pyogenic microbes under different conditions can produce a series of different diseases, for it is now generally accepted that Fehleisen's *streptococcus erysipelatis* is identical with *streptococcus pyogenes*, which is recognized as the cause of very different inflammatory affections. The theory has been advanced by Reger that all the so-called pus-diseases are simply local expressions of a general infection caused by many different micro-organisms.

No surgeon should undertake the performance of an operation or the treatment of an open wound without having clearly impressed upon his mind the important part that pyogenic and specific microbes may play in the subsequent course of the wound.

Sepsis.—Sepsis is due to the entrance and multiplication of microbes or the absorption of their products in the body, and is characterized by local inflammation of the wound, and marked constitutional symptoms, such as fever, disorders of the nervous system, and inflammation of the viscera. Microbic infection represents a pathological process which causes serious wound complications, and differs materially from that process which attends the repair of wounds that run an aseptic course. Aseptic chemical irritation of the tissues may result in the production of a *puruloid* fluid, which is not pus, but merely a fibrinous exudation containing numerous cells, and does not produce infection if injected into animals. Acute suppuration in a wound is considered clinically to be the invariable result of the presence of bacteria, for their exclusion will prevent its occurrence.

Asepsis.—Asepsis aims at thorough sterilization of the parts and of all objects brought in contact with the wound, and the exclusion of germs by occlusive dressings.

Antisepsis.—Antisepsis, on the other hand, is that method of wound treatment which keeps germicidal agents constantly in contact with the wound. The object of antisepsis is, therefore, to produce asepsis.

Since the majority of wound complications are due to the presence in the wound of micro-organisms, it is the duty of the surgeon to prevent their contact with it, or to employ means for their destruction. We must, however, employ means of disinfection or destruction of these micro-organisms which will not have any injurious effect upon the tissues with which they come in contact. Mechanical disinfection is not applicable to wounds, but is employed to remove any micro-organisms which may be present upon the objects which are to come in contact with the wound—namely, the hands of the surgeon and assistants, instruments, and the skin surrounding the wound. Mechanical disinfection is accomplished by the use

of friction with a brush, soap, and water. *Germicidal solutions* may be used for disinfection of wounds, but are most useful in the disinfection of the hands of the operator, the skin of the patient, the instruments, and the dressings. If these have been carefully employed before the wound is made, their subsequent use in the wound is unnecessary.

Some forms of *bacilli* contain spores which often resist the action of germicidal substances, while the bacilli themselves are readily destroyed by these agents: the surgeon should therefore employ that means of disinfection which is generally applicable to the destruction of both bacilli and their spores. The bacilli of *anthrax*, *tuberculosis*, and *tetanus* contain spores; hence to destroy these organisms is a matter of more difficulty than to render harmless such microbes as *staphylococcus pyogenes aureus*, *albus*, and *citreus*, *streptococcus pyogenes* and *streptococcus erysipelatis*, and the bacilli of *diphtheria* and *glanders*, which contain no spores.

Heat is the most reliable, the most easily obtained, and the most generally applicable destroyer of micro-organisms. Heat when used as a germicide cannot be applied to the wound itself, except in cases where a limited amount of the surface of the wound may be touched with the hot iron. Heat can therefore be used only for the disinfection of substances coming in contact with the wound, and for this purpose it is employed in the form of *steam*, *dry heat*, or *boiling water*. No form of micro-organism now known is able to withstand the action of boiling water for a few minutes; spores which can be soaked in germicidal solutions for a week without losing their vitality are destroyed in a few minutes by boiling water.

METHODS OF DISINFECTION OR STERILIZATION.

Sterilization of the wound or the substances coming in contact with it may be accomplished by using either the *aseptic method* or the *antiseptic method*, and at the present time these two methods are to a certain extent combined; that is, it is impossible to be strictly aseptic without employing means of disinfection by the use of antiseptics. The aseptic method, which employs antiseptic substances only for the purpose of sterilization of objects coming in contact with the wound, when their disinfection by heat is impossible, is the method which has been generally adopted.

Antiseptic Method.—In the antiseptic method the sterilization of the field of operation, the hands of the surgeon and assistants, the instruments, ligatures, sponges, and sutures, is accomplished by the use of germicidal solutions, and, in addition, the wound is irrigated frequently during the operation with germicidal solutions, and is afterwards covered with dressings impregnated with germicidal substances. The antiseptic method was that first employed, and, recognizing its value in surgical procedures, many surgeons still continue to employ this method, but it has certain disadvantages. Recent investigations have shown that many of the germicidal substances have not the power which was formerly attributed to them; many chemical germicides form a dense layer of coagulated albumin around albuminous substances, and also fail to destroy micro-organisms associated with fatty or oily substances. *Chemical germicides* may also form combinations in the tissues with substances with which they come in contact, seriously

impairing their germicidal action. Antiseptic substances which are active as germicides often cause irritation of the surface of the wound, interfering with its repair. Halstead has shown that irrigation of a fresh wound with a 1 to 10,000 solution of bichloride of mercury is followed by distinct evidence of superficial necrosis of the tissues. Antiseptic irrigation of wounds is apt to cause very free oozing of serum, which necessitates the use of drainage and makes the frequent dressing of the wound necessary. Many antiseptic substances produce marked toxic effects upon the patient, and also cause very severe irritation of the skin with which they come in contact.

Aseptic Method.—In employing the aseptic method in the treatment of wounds the field of operation, the hands of the surgeon and assistants, the instruments, ligatures, sponges, and sutures, are sterilized by the use of germicidal solutions and heat, and after this has been accomplished, relying upon the completeness of the sterilization, no antiseptic substances are brought in contact with the wound, sterilized water or sterilized salt solution being used if it is necessary to flush the wound, and the dressings employed are those only which have been sterilized by moist or dry heat. The advantages of the aseptic method are as follows: the method is applicable to all parts of the body; wounds treated by this method heal more promptly and do not require such frequent dressing; there is no risk of toxic effects, and there is no irritation of the skin by the dressings. *Dry sterilized dressings* are efficient to produce absorption, and at the same time the dryness may be a factor in the destruction of germs, for exposing bacteria to dryness deprives them of one of the conditions necessary to their existence. The aseptic method is, therefore, to be preferred to the antiseptic method in the treatment of wounds wherever it is possible.

Sterilization of the Hands.—Experimental investigation has shown that the hands of the surgeon, unless properly sterilized, may be the most efficient agents in producing infection of the wound; the region of the *finger-nails* and the *interdigital folds* are locations where germs are particularly abundant. The hands and forearms of the surgeon, assistants, and nurses who are to take part in the operation may be sterilized by first rubbing them with spirit of turpentine, and then thoroughly scrubbing them with Castile soap and water, using a nail-brush freely. Care should be taken that the brush is sterilized. This scrubbing should be employed for several minutes; the hands are then rinsed to remove the soap, and are soaked for two minutes in a 1 to 1000 bichloride of mercury solution. If turpentine has not been employed before washing with the soap, strong alcohol or ether should be well rubbed over the hands before they are immersed in the bichloride solution. When the hands have been sterilized they should not be brought in contact with anything that is not sterile.

Another method of sterilizing the hands which is very satisfactory is that employed by Kelly, which consists in washing the hands and forearms with soap for ten minutes, and then covering them with a warm saturated solution of *permanganate of potassium*, which stains them a deep mahogany color; they are then washed in a warm saturated solution of *oxalic acid* until all the permanganate stain is removed, and should next be washed in sterilized

water to remove the oxalic acid which may adhere to the skin. Weir recommends the following method of sterilizing the hands. After washing them with green soap, put a tablespoonful of commercial chloride of lime and a piece of carbonate of soda ($1 \times \frac{1}{2}$ inch) in the hand, with enough water to make a paste. Rub this into a thick cream, which should be rubbed into the hands until the grains of lime disappear and the skin feels cool. The hands are then rinsed in sterile water.

Sterilization of Instruments.—The sterilization of instruments can be best accomplished by dry or moist heat; they can be placed in a hot-air sterilizer or baked for twenty minutes in a hot oven. Sterilization of instruments by dry heat or baking is not often employed, as it is apt to spoil the temper of the steel. Instruments may be sterilized by the method suggested by Schimmelbusch, now almost universally employed, which consists in boiling them for fifteen minutes in water to which a tablespoonful of washing soda (carbonate of sodium) has been added for each quart of water; this prevents the rusting of the instruments, and also makes the water a better solvent for any fatty matter which may be upon the instruments, thus increasing the sterilizing effect of the heat. If wooden-handled instruments are used, which would be injured by boiling, they should first be thoroughly scrubbed with soap and water and a brush, and after having been rinsed in sterilized water they should be placed in a tray and covered with a 1 to 20 watery solution of carbolic acid, and allowed to remain in this solution for at least half an hour; before being used they should be transferred to a solution of sterilized water, which will prevent the benumbing effect of the carbolic solution upon the surgeon's hands.

Sterilization of Catheters is a matter of great importance. These, if made of metal or glass, may be sterilized by boiling; if of rubber or gum, they should be thoroughly washed and soaked for several hours in a 1 to 1000 bichloride solution, and should be washed in sterilized water before being used.

Preparation of the Patient for Aseptic Operation.—When possible it is well that the patient be given a general bath the night before the operation, and the skin surrounding the site of operation should be rubbed over with cotton saturated with spirit of turpentine, and should then be thoroughly scrubbed with a brush and soap and water; or a soap poultice may be applied to the part for a few hours before the final sterilization with alcohol and bichloride is made. After this scrubbing has been continued for a few minutes the skin is washed with alcohol, and if turpentine has not been used it is better to rub the skin over with ether, then wash it with sterilized water and apply to the surface a folded towel or gauze dressing saturated with a 1 to 1000 bichloride solution; or if a moist dressing is uncomfortable to the patient, a few layers of sterilized gauze should be placed over the surface and held in place by a bandage. A similar washing and preparation of the seat of operation should be made upon the next morning, a few hours before the time fixed for operation.

It is well to remember that regions of the body which contain hair and numerous sweat-glands, such as the axilla, navel, scrotum, groin, and the creases about the joints, are those in which micro-organisms grow with the

greatest activity. All the surrounding hair should be shaved off, and if the operation be upon the skull it is well to shave the scalp completely.

Sterilization of the Feet.—As most patients do not apply water as freely to their feet as to other portions of the body, there is usually present a very large amount of thickened epidermis, which is often a difficult matter to render sterile. The feet should be thoroughly washed with soap and water and scrubbed vigorously with a brush; or a soap poultice should be applied to the whole surface of the feet for some hours and held in position by a bandage. A moist dressing favors the separation of the superficial layers of the epidermis, and after it has been worn for a few hours it is possible to remove a large portion of the epidermis by the use of the brush. After having been thoroughly washed with a 1 to 1000 bichloride solution they should be wrapped in a towel or a few layers of gauze saturated with bichloride of mercury solution 1 to 1000.

Sterilization of the Vagina.—According to Schimmelbusch, the best method of sterilizing the vagina is to scrub it thoroughly with pads of gauze saturated with green soap and water, and after this cleansing to irrigate it with a 1 to 2000 bichloride solution or a one per cent. solution of kreolin.

Sterilization of the Bladder.—It is impossible to employ any method to sterilize completely the mucous membrane of the bladder. The best means we have at our disposal at the present time of sterilizing the mucous membrane of the bladder consists in irrigating the organ frequently with a ten-grain solution of boric acid in boiled water.

Sterilization of the Rectum.—When an operation is to be performed upon the anus and rectum, the patient should be given a purgative and an enema some hours before the operation, to remove any fæcal matter which may be in the rectum. The region of the anus should be disinfected with soap and water and thoroughly scrubbed, and after the patient has been anæsthetized the sphincter should be well stretched and the rectum irrigated with a boric acid solution. A tampon of sterilized gauze, with a string attached, should be packed into the rectum above the seat of operation, to prevent the wound from becoming soiled with fæces during the operation. The tampon can be removed by means of the string after the operation has been completed.

Clothing of Surgeon and Assistants.—It is desirable for the surgeon, his assistants, and the nurses, to be provided with gowns with sleeves reaching to the elbows, for the protection both of the patient and of their clothing. The operating-gown should be made of muslin or linen, which can easily be sterilized by boiling or heat; a variety of linen known as butcher's linen is very serviceable for this purpose. As a matter of additional precaution, many surgeons and their assistants wear during the operation closely fitting skull-caps of linen. The surgeons and assistants will often find it convenient to wear under their linen gowns india-rubber aprons, to prevent the soiling of the clothing by blood or solutions. The nurses, if they do not wear gowns, should wear dresses of washed goods. When the ordinary operating-gowns are not to be obtained, an operating-apron may be improvised from a clean sheet folded so as to be one and a half

yards in width and from six to seven feet in length, by turning in about ten inches of one end of the sheet over the upper part of the chest and placing a strip of bandage in this fold, which should be secured around the neck, and tied by a second strip of bandage over the sheet at the waist.

Preparation of Room for Operation.—In hospital practice suitable operating-rooms are provided; in private practice, however, the surgeon is often called upon to select a room and give directions as to its preparation. A well-lighted room should always be selected, and all unnecessary articles of furniture, such as ornaments, pictures, and curtains, should be removed. The carpet should be taken up, and the floor scrubbed. A few small tables and a large wooden table should be placed in the room, having previously been dusted and wiped off with a bichloride solution. All preparations should be made, if possible, upon the day before the operation, as the stirring up of dust incidental to the change in furniture in cleaning the room on the day of operation immediately before the time set is more dangerous than no cleaning of the room whatever, since the principal contamination of the wound is likely to come from germs contained in the dust. In case of emergency the floor may be well moistened by sprinkling with water to lay the dust. The preparation of the room is not, in our judgment, a matter that affects the results of operations as much as does the exercise of great care in regard to aseptic details of the operation itself. We have performed many serious operations in emergency cases in rooms which were far from clean, the beds occupied by the patients at the time of and after the operation, as well as the patients themselves, being in a filthy condition, yet with rigid observance of the rules of asepsis as regarded the wounds, the latter generally ran a typically aseptic course.

Details of an Aseptic Operation.—The patient, being prepared for operation as described, and having been anæsthetized, is placed upon the operating-table, the surgeon, assistants, and nurses also being prepared for the operation as previously described. If the operation be one upon the face, neck, or chest, it is well before the dressings covering the seat of operation are removed to cover the patient's hair with a towel or handkerchief bandage made of several layers of sterilized or bichloride gauze. The portions of the patient's body which it is not necessary to expose in the operation should be covered with a woollen blanket, and this covered with a sterilized sheet. Some surgeons prefer to have the patient wear a sterilized gown, which is ripped or cut to expose the part to be operated upon. The region of the wound and the operating-table are next protected with sterilized towels or cloths. The surgeon having assigned the assistants and nurses their duties, the dressing is removed from the part to be operated upon, and the operation is begun. Hemorrhage is controlled during the operation by the use of hæmostatic forceps, and sterilized gauze pledgets are employed to keep the wound free from blood. When the operation is completed, the vessels are ligated, the hæmostatic forceps are removed, and the wound is dried with gauze pledgets. If, for any reason, the surgeon deems it advisable to irrigate the wound, it may be done with hot water which has been boiled, or with hot sterilized salt solution. If the surgeon decides that drainage is not necessary, the deeper parts of the wound may then be brought together

by buried sutures of catgut or silk, and the edges of the superficial wound next approximated by sutures of catgut, silk, or silkworm-gut. If the surgeon decides to use drainage, a few strands of catgut, a strip of sterilized gauze, a tent of rubber tissue, or a rubber drainage-tube is introduced into the deepest portion of the wound and is brought out at its most dependent part. The wound is then dressed with a number of loose masses of sterilized gauze placed so as to cover the wound and extend beyond it in all directions, and these are covered by a number of layers of sterilized gauze. Over the gauze dressing are placed a few layers of sterilized cotton, extending on all sides well beyond the gauze, and the dressings are held in place by a sterilized gauze bandage. The dressings should be voluminous; it is always a mistake to apply scanty dressings. In redressing the wound the same care should be exercised as regards asepsis as was observed at the primary dressing.

Details of an Antiseptic Operation.—If the surgeon is about to operate upon a patient in whom a wound exists which is already suppurating, as, for instance, the removal of suppurating glands from the groin, and desires to employ the antiseptic method, the procedure will be as follows. The region of the wound being sterilized, and the surgeon, assistants, and nurses having prepared themselves as before described, the wound is exposed, and if suppurating sinuses exist these are washed out with peroxide of hydrogen, and this application should be followed by a douche of a 1 to 2000 bichloride solution. The surgeon next enlarges the wound and removes the glands as completely as possible, and may during the operation have the wound douched at intervals with bichloride solution, the curette and scissors being used freely to remove diseased tissues. Hemorrhage is controlled by the use of hæmostatic forceps, which are removed later, and bleeding vessels are tied with catgut. The wound is finally irrigated with a warm bichloride solution, is dried with sponges or gauze pledgets, and may be dusted freely with powdered iodoform; a rubber drainage-tube or strips of iodoform gauze are next introduced to the bottom of the wound, and the edges are brought together by sutures; pads of iodoform gauze or bichloride gauze are placed over the wound, and over these a number of layers of bichloride cotton, and the dressings are held in position by a gauze bandage. In redressing such a wound the same antiseptic details should be employed.

Aseptic or Antiseptic Treatment of Infected Wounds.—It often happens that the surgeon is called upon to treat a wound which is septic when it comes under his care, as evidenced by the inflamed state of the wound, inflammation of the lymphatic vessels and skin, foul discharges and sloughing of the tissues, and the coexistent constitutional symptoms of sepsis. In such a case it would at first sight appear that the surgeon or his assistants could not introduce any material of infection worse than that which already existed in the wound, but he should bear in mind the fact that it is possible to introduce a new form of infection in addition to that already existing. With this possibility in view he should observe the same precau tions as regards the sterilization of his hands, the skin of the patient, the instruments, and dressings as he would employ in treating a perfectly fresh wound.

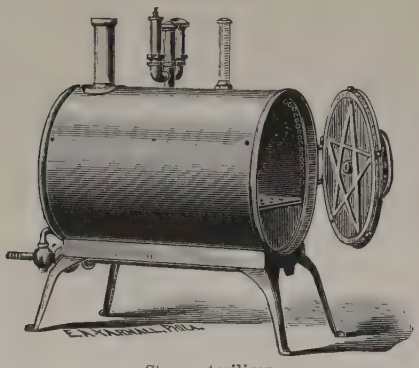
It was formerly the rule to apply the antiseptic method very generally in the treatment of infected wounds. Recent investigations, however, have shown that the germs in abscesses are to a great extent dead, and that the pus-formation is largely due to the irritation caused by their products. In view of these facts, it would seem that the most important part of the treatment of infected wounds is thorough drainage. It is a question whether the micro-organisms in the walls of infected cavities or sinuses can be destroyed by antiseptic irrigation. Some surgeons recommend active treatment, both mechanically and by the use of germicidal solutions, while others are satisfied simply to secure free drainage, and if irrigation is necessary they do not employ strong germicidal fluids, but use simply sterilized water or sterilized salt solution. For our own part we are inclined to employ the antiseptic method in dealing with infected wounds, and can recommend the following plan. The skin surrounding the wound for some distance should be wiped over with spirit of turpentine and carefully scrubbed with soap and water, and should next be washed with a 1 to 1000 bichloride solution; the wound itself should next be washed with peroxide of hydrogen and a 1 to 1000 bichloride solution. With forceps and curette any dirt or sloughing tissue should be removed; then the wound again washed with peroxide of hydrogen and douched with a 1 to 2000 bichloride solution. The wound should then be dried with gauze pledgets and dusted with iodoform and loosely packed with strips of iodoform gauze. If from the appearance of the tissues the surgeon has reason to think that the infection has passed beyond the reach of the curette or scissors, he may swab the surface of the wound over with a solution of chloride of zinc, thirty grains to the ounce of water. Pure carbolic acid may be used, and is recommended by some surgeons, for the same purpose as chloride of zinc, but the toxic action of carbolic acid causes its employment to be attended with some danger. Free drainage being secured by the introduction of a few strips of iodoform gauze, the wound is dressed with a voluminous dressing of bichloride gauze and bichloride cotton. No attempt, as a rule, should be made to bring together the edges of such a wound by the introduction of sutures. In the dressing of infected wounds, when the discharges are ropy or viscid they are not well absorbed by dry dressings, and in this class of wounds it is therefore often of advantage to employ moist antiseptic dressings. By this method of treatment it is often possible to convert a septic wound into an aseptic one, and have rapid improvement follow both in the local condition of the wound and in the constitutional condition of the patient.

AGENTS EMPLOYED TO SECURE ASEPSIS.

A great variety of agents possessing more or less germicidal power have been at different times employed in the practice of aseptic and antiseptic surgery. Those most employed now are heat, bichloride of mercury, carbolic acid, iodoform, beta-naphtol, chloride of zinc, sulphocarbolate of zinc, acetate of aluminum, peroxide of hydrogen, pyrozone, kreolin, permanganate of potassium, pyoktanin, boric acid, salicylic acid, aristol, and iodol.

Heat.—Heat, either dry or moist, is the most reliable and most universally valuable agent for the destruction of micro-organisms. Many forms of bacteria are rendered inert by a temperature of 140° F. (60° C.), and no organisms can withstand a continued application of moist heat reaching 212° F. (100° C.). As moist heat is the most efficient sterilizer, it should be preferred; boiling instruments and dressings for a few minutes will completely sterilize them. Steam sterilizers may also be employed for this purpose. (Fig. 90.)

Fig. 90.



Steam sterilizer.

Sterilization may also be satisfactorily accomplished by the employment of dry heat, the dressings being baked for half an hour in a hot oven or being placed in a dry sterilizer.

An improvised sterilizer may be made by having a perforated metal stand placed inside of a large kettle so that only the steam comes in contact with the instruments and dressings.

Bichloride of Mercury.—This is employed as an antiseptic in watery solutions varying in strength from 1 to 500 to 1 to 10,000. A solution of 1 to 1000 is used for disinfection of the hands and skin, and a 1 to 2000 to 1 to 4000 solution is generally employed for the irrigation of wounds. In using bichloride solution the surgeon should watch the patient carefully for symptoms of poisoning through the absorption of the drug, which are generally manifested by vomiting, fetid breath, salivation, inflammation of the gums, diarrhœa, and blood-stained stools. It will be found convenient to have a concentrated solution of bichloride in alcohol, one part of the bichloride to ten parts of alcohol; to this should be added one teaspoonful of common salt, which prevents the disintegration of the mercuric compound. A ten per cent. bichloride solution may be made as follows: bichloride of mercury, 2 parts; sodium chloride, 1 part; dilute acetic acid, 1 part; water, 16 parts. By adding water in proper quantity a 1 to 1000 or 1 to 2000 solution may be made. A *tartaric acid* solution of bichloride is also prepared as follows: hydrarg. chlor. corrosiv., gr. xv; acid. tartaric., gr. lxxv; aquæ dest., Oij.

In private practice the most convenient method of making bichloride solution is by the use of bichloride pellets, which contain a definite amount of bichloride of mercury, mixed with a few grains of common salt. These are dissolved in the requisite amount of water to make a solution of the strength desired.

Carbolic Acid.—Carbolic acid was the first antiseptic recommended and used by Lister, and was popular as an antiseptic until it was found that bichloride of mercury possessed more decided germicidal action. This drug is employed in watery solutions 1 to 20 or 1 to 60. A 1 to 20 solution is usually employed for the sterilization of instruments, the latter being allowed to remain in the solution for thirty minutes before being used: a

solution of this strength benumbs and cracks the skin of the surgeon's hands, and it should therefore be diluted before the instruments are required by adding an equal quantity of hot water. A 1 to 60 solution is employed in the irrigation of wounds and the washing of sponges. A ready method of making a five per cent. carbolic solution is to add one tablespoonful of carbolic acid to one pint and a half of water. The continued use of carbolic acid solution may give rise to poisoning, which will show itself by dark-colored urine, headache, dizziness, vomiting, and in some cases bloody diarrhœa, hæmoglobinuria, collapse, and death. The use of weak solutions of carbolic acid seems to involve more risk of toxic action than does the employment of the pure drug, the superficial layer of tissue being coagulated by the latter, so that the absorption of the drug is prevented. Gangrene of the skin and subjacent tissues has frequently been observed to follow the long-continued use of quite dilute solutions of carbolic acid or of ointments containing small quantities of the drug. Cases of gangrene of the fingers and toes from this cause are not infrequently seen. (Fig. 91.) Infants and children seem especially susceptible to the poisonous action of carbolic acid. We have seen the use of dilute solutions produce the characteristic symptoms of poisoning in such patients. Fatal poisoning has followed the application of a 1 to 40 solution to small wounds, such as the wound of circumcision.

Fig. 91.

Gangrene of toes from carbolic acid dressing.

Iodoform.—Iodoform has been shown by experimental research to possess little direct germicidal action, but in spite of this fact clinical experience has proved that it possesses powerful antiseptic properties, due, as shown by Behring and De Ruyter, not to the destruction of germs, but to its undergoing a decomposition in their presence and thus rendering inert the ptomaines which have resulted from the germ-growth. It may be rendered absolutely sterile by exposing it to heat, and, as it is easily decomposed, fractional sterilization may be employed, or by washing it in a 1 to 1000 bichloride solution; it should then be dried and kept for use in closely stoppered bottles. Iodoform is very extensively employed as an application to wounds. It is frequently employed in aseptic wounds which are liable from their position to become infected, such as wounds about the mouth, rectum, and vagina, and is especially useful as a dressing in infected wounds and in tubercular or syphilitic ulcers. In operations upon the mouth, anus, rectum, uterus, and abdominal cavity iodoform gauze packing is largely employed, and serves to keep the discharges from becoming foul, thus often preventing septic intoxication. Iodoform may be used in the form of powder. *Iodoform collodion*, made by adding iodoform, gr. xlviii, to collodion, f℥i, is a useful dressing in superficial wounds. It may be also employed in the form of an *ethereal solution*, iodoform, gr. xv, ether, f℥i, as an application to wounds or ulcers. An *emulsion of iodoform*

in glycerin, iodoform, ʒi, glycerin, ʒx. or an emulsion of iodoform made by adding sterilized iodoform, ʒi, to boiled olive oil, ʒx, is much employed as an injection in the treatment of tubercular abscesses and joints. We have seldom seen any toxic effects follow the use of iodoform, although numerous cases have been reported in which toxic symptoms were observed, such as urticarial eruptions, headache, depression, delirium, mania becoming permanent, debility, and sleeplessness, and sometimes heart derangements. Elderly persons and infants are more prone to the toxic action of iodoform than young persons or adults.

Aristol.—Aristol, which is a compound of iodine and thymol, has been introduced as a substitute for iodoform. It is said to produce no toxic effects, and is without disagreeable odor, but clinically it does not compare in value with iodoform. It may be employed for the same purpose as iodoform, and it seems to be particularly useful as a dressing for chronic and specific ulcers.

Iodol.—This drug possesses antiseptic properties, and is employed for the same purpose as iodoform and aristol. It has much less odor than the former, is soluble in alcohol, ether, and oil, and may be used in the form of a solution or in dry powder. It is used for the same purpose as iodoform, and is much employed as a local application in inflammatory and ulcerated conditions of the mucous membrane of the nose and throat.

Acetate of Aluminum.—This substance is prepared by adding sugar of lead, 5 parts, to a solution of 5 parts of alum in 500 parts of distilled water. It has decided germicidal qualities, is employed for irrigation and moist dressing where carbolic or bichloride solutions cannot be used, and is by all means the safest and best antiseptic substance for wet dressings.

Beta-Naphtol.—Beta-naphtol is employed for much the same purpose as bichloride of mercury, and is used in 1 to 2500 solution, but is not so powerful a germicide. As it does not possess marked toxic qualities, it is employed in the irrigation of large cavities, and as it does not corrode instruments, it is especially useful as a bath for them. It is also used as a substitute for the carbolic acid solution, as it possesses the advantage of not irritating the skin of the surgeon's hands.

Chloride of Zinc.—Chloride of zinc in a solution of 15 to 30 grains to an ounce of water has marked antiseptic properties. When employed in solutions of this strength upon raw surfaces it produces marked blanching of the tissues, and is especially useful as an application to infected wounds. We have found it the best application in infected wounds which are received in the dissection of dead bodies and in operations. In such cases the whole surface of the wound should be swabbed with a thirty-grain solution of chloride of zinc, and the wound then dressed with iodoform or bichloride gauze.

Sulpho-Carbolate of Zinc.—This drug is less irritating than chloride of zinc, and possesses the same antiseptic properties. It is used in solutions of the same strength and for the same purpose as the chloride.

Peroxide of Hydrogen.—Peroxide of hydrogen is employed in what is known as the 15-volume solution. It may be used in this strength or may be diluted. It seems to have a direct action upon pus-generation by de-

stroying the micro-organisms of pus, and is frequently employed in the sterilization of sinuses or suppurating cavities such as remain after the opening of abscesses or result from diseases of or operations upon the bones. It is injected into the sinuses and cavities by means of a glass syringe, or may be applied to open wounds in the form of a spray. Its action is shown by the escape of bubbles of gas, which cleanse suppurating surfaces or sinuses mechanically, and it should be used as long as these continue to escape.

Kreolin.—Kreolin is obtained from English coal-tar by dry distillation, and has been found to possess marked germicidal properties. It is insoluble in water, but forms an emulsion with it which possesses decided germicidal properties. It is used in an emulsion of from two to five per cent. strength in the irrigation of large wounds or cavities of the body, and has been most favorably recommended in gynæcological practice. It is employed for the same purpose as carbolic acid, and has the advantage over the latter drug that it does not irritate the skin and is practically non-toxic. It is used as a bath for the sterilization of instruments during operations, but the opacity of the emulsion makes it difficult to find the instruments.

Boric Acid.—Boric acid does not possess very active antiseptic qualities, but is non-irritating even in saturated solutions. It is frequently employed as a powder and in solutions of from five to thirty per cent. to cleanse and disinfect mucous surfaces and large cavities. On account of its non-irritating qualities it is frequently used to wash out the bladder before operations for the removal of calculi or growths from this organ. In the dressing of wounds in which bichloride or carbolic dressings produce irritation of the skin, or of superficial wounds or extensive burns, an ointment of boric acid 1 part to petroleum 5 parts will be found very satisfactory.

Salicylic Acid.—Salicylic acid does not have very marked antiseptic qualities, but possesses much less toxic action than carbolic acid, and is used for somewhat the same purposes. Its antiseptic power is said to be increased by the addition of boric acid, and a boro-salicylic lotion (Thiersch's solution) is prepared by adding salicylic acid 1 part, boric acid 6 parts, to hot water 500 parts, making a very bland solution, which, when reduced from twenty-five to fifty per cent. in strength, can be used for irrigation of the bladder or the peritoneal cavity.

Permanganate of Potassium.—Permanganate of potassium acts as an antiseptic by its rapid absorption of oxygen, and is often employed for the disinfection of foul wounds and ulcers. It is also used in solution in disinfecting the hands before operation and for the disinfection of sponges. It is non-irritating, and may be used in quite concentrated solutions. It is usually employed in the following solution: potassii permanganatis, ʒi; aquæ, fʒi. One drachm of this solution to a pint of water makes a 1 to 1000 solution.

Pyoktanin.—Pyoktanin, known in commerce under the name of methyl-violet, possesses decided antiseptic powers. It is said to prevent suppuration by destroying the organisms which are active in its production, they having an affinity for and being killed by aniline colors. It has been asserted that it sterilizes the pus of suppurating wounds and ulcers, and as it is practically non-poisonous it is recommended as an injection in the

treatment of large suppurating cavities. It may be used in a solution of the strength of 1 to 1000 or 1 to 12,000, and for the sterilization of instruments a solution of 1 to 1000 may be employed. When employed in the irrigation of wounds it should be used until the tissues are stained a deep blue color; this staining of the tissues is one objection to its use as an antiseptic. It has been shown by recent investigations, however, that pyoktanin is a much less reliable germicide than bichloride of mercury.

PREPARATION OF MATERIALS USED IN ASEPTIC OPERATIONS.

Sponges.—Marine sponges are the best materials for the purpose of sponging, but their satisfactory sterilization is often a matter of difficulty. It is better to use a cheap grade of sponges and use them only once. The sterilization of sponges by boiling destroys to a certain extent their elasticity and their absorbent power. Schimmelbusch recommends the following method. The dried sponges are freed from dirt or sand by beating, and are then soaked for several days in cold water slightly acidulated with hydrochloric acid, being kneaded from time to time. They are next thoroughly washed in cold and in warm water, wrapped up in a linen sheet, and placed in a boiling one per cent. soda solution; the solution should not be allowed to boil after the sponges are placed in it. They are allowed to remain in this hot solution for thirty minutes, are then washed in boiled water to remove the soda, and are placed in a half per cent. bichloride solution for use. Another method of preparing the sponges consists in beating them to remove any sandy matter which they may contain, and placing them for twenty-four hours in a solution of hydrochloric acid, 4 ounces; water, 4 pints; upon removing them from this solution, they are washed until free from acid; they are then placed for half an hour in a solution of permanganate of potassium, 180 grains to 6 pints of water; next they are washed and placed in a solution of hyposulphite of sodium, 10 ounces; hydrochloric acid, 5 ounces; water, 48 ounces, and allowed to remain in this solution for four hours; then they are removed and placed in running water for six hours, and afterwards in a five per cent. carbolic acid solution or a 1 to 1000 bichloride solution. The carbolic acid is the better one for keeping the sponges, as it is not so liable to decomposition.

Gauze Pledgets or Pads.—On account of the difficulty of the satisfactory sterilization of sponges, as well as of their expense, folded gauze pledgets have largely superseded them. **Gauze pledgets** are prepared by cutting a piece of gauze composed of from twelve to sixteen layers in pieces six inches square; the four angles of these pieces are then tied together or secured by a few stitches. **Gauze pads** are made from a piece of gauze composed of from sixteen to twenty layers cut the desired size, the different layers in each pad being quilted together by a few stitches, and the edges loosely whipped with a thread to prevent them from fraying. Gauze pads are used as a substitute for the flat sponges formerly employed in abdominal surgery, and for the drying of wounds. The pads or pledgets may be sterilized by boiling or by exposure to steam or dry heat in a sterilizer, or may be sterilized and preserved at the same time in a 1 to 2000

bichloride solution. When so preserved, before being employed the moisture should be squeezed from them, or they should be washed in water which has been boiled before being brought in contact with the wound.

Silk.—Silk for sutures or ligatures should be sterilized by boiling it for thirty minutes, after which it is to be placed in stoppered bottles and covered with a five per cent. solution of carbolic acid in alcohol, or in ninety-five per cent. alcohol, or in 1 to 1000 bichloride and alcohol solution.

Silkworm-Gut.—Silkworm-gut is an excellent material for sutures, and may be sterilized by boiling it for fifteen minutes, or by placing it for one-half hour in a five per cent. carbolic solution: after being sterilized it should be kept in ninety-five per cent. alcohol. There has recently been introduced an iron-dyed black silkworm-gut, which makes the sutures more prominent and thus facilitates their removal.

Catgut Ligatures and Sutures.—Catgut is the ideal material for ligatures and sutures, but has the disadvantages of difficulty and uncertainty in its sterilization. Raw catgut is often infected with microbes, and therefore thorough sterilization alone can render it a safe material for ligatures and sutures.

Von Bergmann's method of preparing catgut, which we have found one of the most satisfactory, consists in winding the catgut loosely upon glass rods or spools; these spools are placed in ether for twenty-four hours; the ether is then poured off, and the catgut is placed in the following solution: bichloride of mercury, 10 parts; absolute alcohol, 800 parts; distilled water, 200 parts. Remove from this solution in twenty-four hours, and place it in a similar solution for forty-eight hours; then place it in absolute alcohol. If you desire the gut to be soft, add twenty per cent. of glycerin to the absolute alcohol. To make the sterilization absolutely certain it has been found advantageous to soak the catgut for thirty minutes in a 1 to 1000 aqueous bichloride solution before placing it in the alcoholic solution of bichloride.

Catgut may also be sterilized by **boiling.** The most satisfactory method is that devised by Fowler, which consists in placing a number of strands of catgut in an ordinary test-tube which is filled with ninety-five per cent. alcohol to within half an inch of the top; a wad of cotton is next pushed into the mouth of the tube, and a cork is introduced. The tubes thus prepared are placed inverted in a fruit-jar filled with ninety-five per cent. alcohol; the jar is then closed and placed in a water-bath and kept at a boiling temperature for an hour.

Formalin Catgut.—This is prepared by winding catgut loosely on glass spools and keeping them for forty-eight hours in a vessel containing equal parts of alcohol and ether. They should next be washed for a few minutes in alcohol and placed in a jar containing equal parts of alcohol and formalin, and allowed to remain for several days. The excess of formalin should then be washed away with alcohol, and the catgut kept for use in ninety-five per cent. alcohol.

Bichloride of Palladium Catgut.—Catgut should be soaked in ether from twenty-four to forty-eight hours, according to the size of the gut. It is then placed in a mixture of mercuric bichloride, 40 grains; tartaric acid,

200 grains; alcohol (ninety-five per cent.), 12 fluidounces, and allowed to remain from five to twenty-five minutes, according to the size of the gut. Then place it in a sterilized jar containing palladium bichloride grain $\frac{1}{16}$ to alcohol 1 pint, in which it may be kept indefinitely.

Chromic Acid Catgut.—Owing to the fact that it undergoes very slow solution in the tissues, chromic acid catgut is often of service for sutures or for the ligation of the larger vessels in their continuity. Chromic acid catgut may be prepared by placing catgut which has been sterilized by being treated with the alcoholic bichloride solution in one quart of a five per cent. carbolic acid solution which contains thirty grains of bichromate of potassium, allowing it to remain for forty-eight hours; this immersion should be longer when the larger sizes of catgut are used, but for the sizes of catgut which are ordinarily employed this length of immersion will prepare the gut to resist the action of the living tissues for a week or more. Chromic acid catgut thus prepared may be dried and placed in closely stoppered jars, or may be kept in absolute alcohol. Before being used it should be soaked for thirty minutes in a five per cent. carbolic solution or a 1 to 2000 bichloride solution.

FIG. 92.

Catgut-carrier.

FIG. 93.

Rubber drainage-tube.

FIG. 94.

Glass drainage-tube.

A very simple method of carrying catgut and keeping it sterile consists in using a strong glass tube, about an inch in diameter and six inches in length, into each end of which is fastened a rubber cork. A number of glass spools wound with sterilized catgut of various sizes are fitted into this glass tube; one cork is introduced; the tube is then filled with alcohol or a 1 to 2000 bichloride solution in alcohol, and the other cork is introduced, or a test-tube and a rubber stopper may be used. (Fig. 92.)

Drainage-Tubes.—The drainage-tubes usually employed are prepared of rubber tubing of different sizes, perforated at short intervals. (Fig. 93.) Drainage-tubes are also made of glass: these are almost exclusively used in abdominal surgery. (Fig. 94.) Glass drainage-tubes can be sterilized by boiling. Rubber drainage-tubes may also be sterilized by boiling for five minutes, but if kept in boiling water for any greater length of time they are destroyed. After being removed from the boiling water the tubes should be placed in a five per cent. carbolic solution or 1 to 1000 bichloride solution for thirty minutes before being used. *Capillary* drainage is often employed in wounds, and is obtained by the use of a number of strands of catgut or of horse-hair. When used for this purpose, great care should be taken that the sterilization of the material is complete.

Horse-hair drains may be sterilized by thoroughly washing them with soap and water and allowing them to remain for some days in a 1 to 1000 bichloride solution in alcohol.

Protective.—This is a material resembling oiled silk, which is employed to prevent the wound from being irritated by the antiseptic substances with which the gauze is impregnated, or to keep the wound in a moist condition. Various materials may be employed as protectives, the particular requirement being that they can be readily rendered aseptic and will not absorb any irritating materials from the dressings. The protective employed by Mr. Lister was prepared by coating oiled silk with copal varnish; when this had dried, a mixture of 1 part of dextrin to 2 parts of powdered starch and 16 parts of a 1 to 20 carbolic solution was brushed over its surface.

Rubber Dam.—Rubber dam is a thin, pure rubber tissue, which is cleansed and sterilized with great ease. It is sterilized by washing it with soap and water and then placing it in a bichloride or carbolic solution for a short time. It may be used in the moist method of dressing to cover the gauze dressings, and is also attached to the drainage-tube in abdominal wounds to shut off the opening of the tube from the abdominal wound.

Rubber Tissue.—Rubber tissue consists of a very thin sheet of india-rubber with glazed surface. It is employed for the same purposes as mackintosh, is much less expensive, and may be used instead of protective for covering the wound. It is sterilized by soaking it in a carbolic or bichloride solution.

GAUZE DRESSINGS.

The most convenient and cheapest material for wound dressing is a material known to the trade as cheese-cloth or tobacco-cloth, and for surgical use should contain no sizing. From the fact that it has a very open mesh, it absorbs well either the materials with which it is prepared or the discharges from the wound, and is soft and pliable, so that it is a comfortable form of dressing to the patient.

Bichloride or Corrosive Sublimate Gauze.—Bichloride or corrosive sublimate gauze is prepared by placing cheese-cloth in a washing-kettle and covering it with water to which is added two pounds of washing soda or a pint of lye; the latter is added to remove any oily matter which the cheese-cloth contains, thus making it more absorbent. The gauze is boiled in this solution for an hour, and is then removed and washed in boiled water and passed through a sterilized clothes-wringer; it is then immersed in a 1 to 1000 bichloride solution for twenty-four hours; the excess of fluid is then squeezed out of it, and it may be packed in air-tight jars and preserved as a moist gauze, or may be dried in a warm oven and packed in sterilized jars and kept as a dry gauze.

Iodoform Gauze.—Iodoform gauze may be prepared by sprinkling cheese-cloth which has been boiled in soda solution with powdered iodoform which has also been sterilized, and rubbing it well into its meshes; it should then be packed in closely covered glass jars. Iodoform gauze may also be prepared by rubbing an emulsion of iodoform, made by adding 3

drachms of iodoform to 6 ounces of Castile soapsuds, into 18 ounces of moist sterilized gauze; or by saturating boiled sterilized gauze with a solution of iodoform in ether, then allowing the ether to evaporate rapidly, the iodoform thus being evenly distributed through the tissue of the gauze; this should be dried and kept in jars for use. The iodoform gauze in general use contains about ten per cent. of iodoform by weight.

Carbolized Gauze.—In preparing carbolized gauze, cheese-cloth which has been previously boiled and dried is soaked for a few hours in the following solution: resin, 1 pint; alcohol, 5 pints; castor oil, 24 ounces; carbolic acid, 12 ounces. The gauze is removed from this solution and passed through a clothes-wringer, and is then cut into pieces from four to six yards in length, which are folded and packed in air-tight jars for use.

Many other varieties of gauze, such as pyoktanin gauze, salicylated gauze, and borated gauze, are prepared, but, as they are expensive and not so satisfactory as those just mentioned, they are not much employed.

Improvised Aseptic or Antiseptic Dressings.—Aseptic dressings in cases of emergency may be improvised, where the ordinary gauze dressings cannot be obtained, by tearing a piece of muslin or mosquito netting into pieces half a yard square and throwing them into boiling water for a few minutes; they are then removed, the excess of moisture is wrung out of them, and they are applied to cover the wound.

If it is desirable, they may be used as antiseptic dressings by soaking them for a few minutes in a 1 to 1000 or 1 to 2000 bichloride solution, or in a five per cent. carbolic solution. This dressing will keep the wound aseptic until a more elaborate dressing can be obtained.

Aseptic or Antiseptic Bandages.—Aseptic bandages are prepared by tearing or cutting gauze into strips from two and a half to three inches in width and forming these strips into rollers, which are sterilized by boiling or dry heat. They should be used soon after being prepared, or, if kept for any time, should be resterilized before being used.

Antiseptic bandages may be prepared from bichloride or carbolized gauze, but before being used, to render their sterilization more complete, may be soaked for a few minutes in a 1 to 1000 bichloride or a five per cent. carbolic solution.

Bichloride Cotton.—This material is prepared by soaking absorbent cotton in a 1 to 1000 bichloride solution for twenty-four hours, and allowing it to dry, or it may be dried in a hot oven; when dry it is packed in jars or in air-tight boxes. Several layers of bichloride cotton are usually applied over the gauze dressing, as its great absorbing power and elasticity make it, when properly prepared, a most valuable dressing. Borated, carbolized, and salicylated cotton prepared in the same manner are also frequently employed for similar purposes.

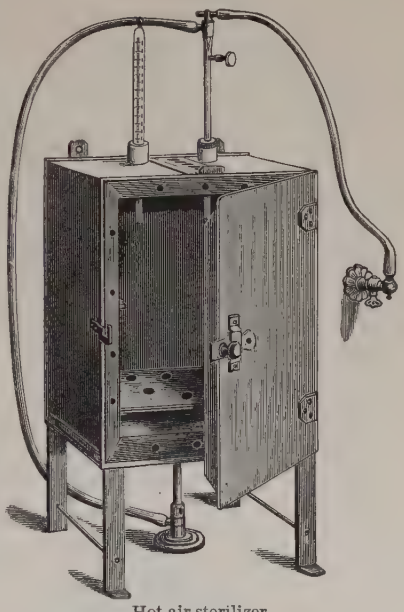
Sterilized Cotton.—Sterilized cotton is prepared by placing absorbent cotton, enclosed in perforated metal cans, in a steam sterilizer and allowing it to remain for several hours. It is used for the same purposes in dressings as the bichloride cotton.

Moist Sterilized Gauze Dressings.—Moist sterilized gauze dressings are prepared by subjecting gauze which has been boiled in soda solu-

tion to the action of boiling water or of steam for thirty minutes. Gauze thus prepared should be used as soon as prepared.

Sterilized gauze may also be prepared by putting rolls or pieces of gauze, cut from eight to twelve inches square, into cylindrical tin boxes, three inches in diameter and eight inches in height, with perforated metal covers, and covering the gauze at each end of the cylinder with a layer of cotton before putting on the covers. They should next be placed in a steam sterilizer for an hour or two, and when taken out may be kept with safety for some time if the cotton coverings are not disturbed. Cotton can be sterilized and kept in the same way.

Fig. 95.



Hot-air sterilizer.

Dry Sterilized Gauze Dressings.—Dry sterilized gauze dressings are prepared by cutting gauze into proper lengths and packing it loosely in wire cages or perforated metal cans, which are next placed in a dry sterilizing-oven for several hours, and upon removal it is placed in air-tight jars or metal boxes. In using sterilized gauze dressings it is safer to have the dressings freshly sterilized immediately before each operation.

The apparatus required for the dry sterilization of dressings is expensive, and is not likely to be employed by the general practitioner, but is used largely in hospitals, where large numbers of dressings are constantly required. A convenient form of sterilizing-oven is shown in Fig. 95. Towels and operating-gowns can be sterilized in the same oven.

Surgical Operating-Bag.—For operations in private practice the surgeon will find it convenient to have a bag or kit containing gauze dressings, bichloride pellets, carbolic acid, alcohol, turpentine, ligatures, sutures, needles, syringes, a metal tray in which instruments can be boiled, a nest of agate-ware basins, sponges, gauze pads, a sheet of rubber cloth, drainage-tubes, and operating-gown. These can all be packed in a comparatively small space, and when the surgeon is called upon to perform any special operation at short notice the instruments required may be selected, wrapped in a Canton flannel scroll, and placed in the bag. Much time will be saved by having the materials required in operations always in readiness in such a bag.

CHAPTER IX.

MINOR SURGERY.

BANDAGING.

BANDAGES are usually prepared from strips of muslin, flannel, crinoline, or cheese-cloth, which are rolled into the form of a cylinder, and are employed to hold dressings in contact with the surface of the body, to make pressure, or to retain splints in place in the treatment of fractures or dislocations. The ordinary roller bandage consists of a strip of woven material, usually unbleached muslin, but cheese-cloth may also be employed, which varies in length from one to nine yards and in width from one inch to four inches; this, for convenience of application, is rolled into a cylindrical form. In preparing the roller bandages it is important that they should be free from seams and selvage, for if made of a number of pieces sewed together, or if they contain selvage, they cannot be so neatly applied and are apt to leave creases upon the skin of the patient. In preparing the ordinary roller bandage, muslin or cheese-cloth is torn into strips, and is then rolled into a cylinder, either by the hand or by a machine constructed for the purpose. To roll a bandage by hand, the strip should be folded at one extremity several times until a small cylinder is formed; this is then grasped by the extremities between the thumb and finger of the left hand; the free extremity of the strip is then grasped by the thumb and index finger of the right hand, and by alternating pronation and supination of the right hand the cylinder is revolved and the roller is formed. (Fig. 96.)

FIG. 96.

Rolling bandage by hand.

Dimensions of Bandages.—Bandages vary in length and width according to the purposes for which they are employed.

Bandage *one* inch wide, *three* yards in length, for bandages for the hand, fingers, and toes.

Bandage *two* inches wide, *six* yards in length, for head bandages and for the extremities in children.

Bandage *two and a half* inches wide, *seven* yards in length, for bandages

of the extremities in adults; a bandage of this size is the one usually employed in general surgical work.

Bandage *three* inches wide, *nine* yards in length, for bandages of the thigh, groin, and trunk.

Bandage *four* inches wide, *ten* yards in length, for bandages of the trunk.

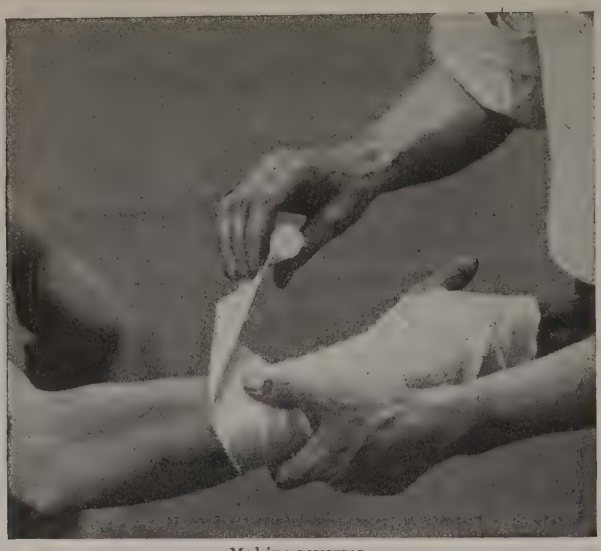
Rules for Bandaging.—In applying a roller bandage the operator should place the external surface of the free extremity of the roller upon the part and hold it in position with the fingers of the left hand until the end is fixed by a few turns of the roller; the roller should be held in the right hand by the thumb and fingers, and as the bandage is unwound it rolls into the operator's hands; the turns should be applied smoothly to the surface, the pressure exerted by each turn being uniform. In applying a bandage over the region of a joint the surgeon should see that the part is in the position it is to occupy as regards flexion and extension when the dressing is completed, for a bandage applied when the limb is flexed will exert too much pressure when the limb is extended; if applied when the limb is extended it will be found uncomfortable upon flexion, and may even exert dangerous compression of the part. Those who have had little experience with the application of the roller bandage are apt to apply their bandages too tightly, which may lead to dangerous consequences, especially in the dressing of fractures. When the bandage has been applied to a part, the extremity should be secured by a pin or safety-pin. The bandage may be removed by cutting its folds with scissors made for this purpose, or, if it is desired to preserve the bandage, it may be removed by unpinning the terminal extremity and gathering the folds carefully into a loose mass as the bandage is unwound, the mass being transferred rapidly from one hand to the other, thus facilitating its removal and preventing the part from becoming entangled in its loops.

SPECIAL BANDAGES.

Spiral Reversed Bandage.—This bandage is a spiral bandage, but differs from the ordinary spiral bandage in that its turns are folded back or reversed as it ascends a part the diameter of which gradually increases. It is possible by the use of this bandage to cover by spiral reversed turns a part conical in shape, and so make equable pressure upon all parts of the surface. It requires skill and practice to apply this bandage neatly; a well-applied spiral reversed bandage is a test of a competent bandager. Reverses are made as follows: the initial extremity of the roller is fixed, and as the part increases in diameter the bandage is carried off a little obliquely to the axis of the limb for from four to six inches; the index finger or thumb of the disengaged hand is placed upon the body of the bandage to keep it securely in place upon the limb, while the hand holding the roller is carried a little towards the limb, to slacken the unwound portion of the bandage, and by changing the position of the hand holding the bandage from extreme supination to pronation the reverse is made. (Fig. 97.) The reverse should not be made while the bandage is tense, for by so doing the bandage is twisted into a cord, which is unsightly and uncomfortable

to the patient; the reverse should be completely made before the bandage is carried around the limb, and when it has been completed it should be

Fig. 97.

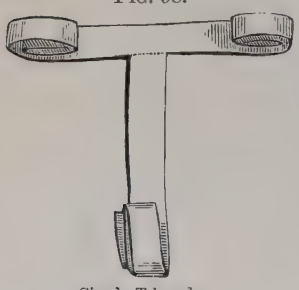


Making reverses.

slightly tightened, so as to conform accurately to the part. The reverses should not be made over salient parts of the skeleton, and should be kept in line.

Compound Bandages.—Compound bandages are usually formed of several pieces of muslin or other material three or four inches in width, sewed or pinned together, and are employed to fulfil some special indication in the application of dressings to particular parts of the body. The most useful of the compound bandages are the T-bandages and many-tailed bandages. A single T-bandage consists of a horizontal band, to which is attached, about its middle, another having a vertical direction; the horizontal piece should be about twice the length of the vertical piece. (Fig. 98.) A single T-bandage is often employed in applying dressings to the anal region or the perineum, or as a means of securing a catheter in a perineal wound.

Fig. 98.



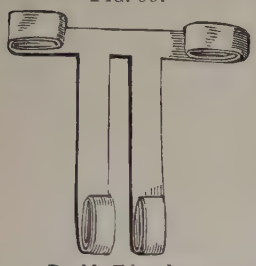
Single T-bandage.

An *oblique T-bandage* is often employed to hold dressings to herniæ, and consists of a strip of material secured around the waist, to which is fastened another strip obliquely so that it can be brought down over the seat of the hernia and passed under the inner side of the thigh and fastened to the horizontal strip upon the back.

Double T-Bandages.—A double T-bandage has two vertical strips attached to the horizontal strip (Fig. 99), and may be used for much the same

purpose as the single T-bandage; it may be used for retaining dressings to the chest, back, or abdomen; when employed for this purpose the horizontal portion should be from eight to twelve inches wide, and long enough to pass one and a quarter times about the chest; two vertical strips, each two inches wide and twenty inches long, should be attached to the horizontal strip a short distance apart, near its middle. In applying this bandage to the chest the horizontal strip is placed around the chest so that the vertical strips occupy a position on either side of the spine; the overlapping end of the horizontal portion is secured by pins or safety-pins, and the vertical strips are next carried one over either shoulder and secured to the other portion of the bandage in front of the chest.

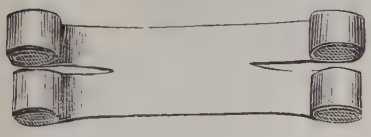
Fig. 99.



Double T-bandage.

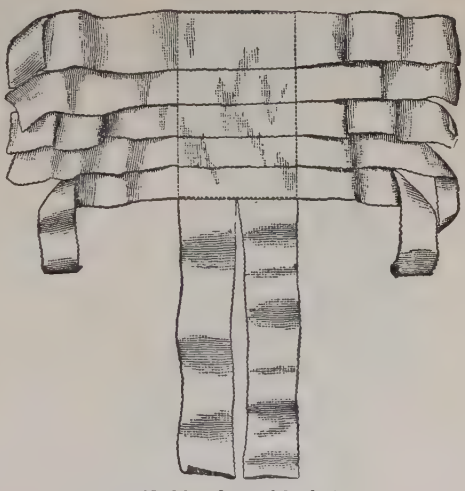
Many-Tailed Bandages or Slings.—Many-tailed bandages are prepared from pieces of muslin of various lengths and breadths, which are split at each extremity into two or three or more tails up to within a few inches of the centre, their width and length being regulated by the part of the body to which they are to be applied. (Fig. 100.) Four-tailed bandages may be found useful as temporary dressings in cases of fracture of the jaw or clavicle or in retaining dressings to the scalp. The many-tailed bandage may also be used in holding dressings in contact with the abdomen or trunk, and is the bandage which most surgeons employ to hold dressings to the laparotomy wound and to give support to the abdominal walls after this operation. In preparing this bandage for the abdomen, a strip of muslin or flannel, one and a half yards in length and from eighteen to twenty inches in width, has the extremities split so as to form an eight-tailed bandage; or a modified bandage of Scultetus, which is made by stitching together in their centre a number of overlapping strips of flannel about three or four inches in width, may be employed. (Fig. 101.) In applying this bandage to the abdomen the body of the bandage is placed under the patient's back, and the tails are brought around the abdomen and made to overlap each other, and when firmly drawn to make the desired amount of pressure they are secured by means of safety-pins.

Fig. 100.



Four-tailed sling.

Fig. 101.



Modified bandage of Scultetus.

HANDKERCHIEF BANDAGES.

Bandages may be applied by means of handkerchiefs or square pieces of muslin for a temporary or permanent dressing in wounds or fractures. Many handkerchief bandages have been devised and employed, and for the application of temporary dressings, where the ordinary roller bandages cannot be obtained, their use will often prove satisfactory. Handkerchiefs may be folded so as to form an oblong or a triangle, or a cravat, or a cord. The names of the various handkerchief bandages are derived from the shape of the handkerchief used and the parts to which they are to be applied. The names serve as guides to their application. The handkerchief bandages may be used to take the place of the ordinary roller bandage; for instance, the bis-axillary cravat may be used as a substitute for the spica bandage of the shoulder, and the mento-vertico-occipital cravat modified may be used to take the place of the Barton's bandage of the head.

Bis-axillary Cravat.—This handkerchief is applied by placing the body of the cravat in the axilla and bringing the ends up, one in front of the axilla, the other behind it, and making them cross over the top of the shoulder, then carrying the extremities across the back and chest respectively to the opposite axilla, where they are secured by

Fig. 102.

Bis-axillary cravat.

Fig. 103.

Mento-vertico-occipital cravat.

tying or by a safety-pin. (Fig. 102.) This handkerchief may be employed to secure dressings in the axilla or to hold dressings in contact with the shoulder.

The Mento-Vertico-Occipital Cravat.—This handkerchief is applied by placing the base of the cravat under the chin and carrying the extremities over the vertex of the skull, crossing them at that point, then carrying them downward to the occiput and crossing them again here, passing them forward around the chin, and finally securing the ends by a knot or pin. The turns of this handkerchief correspond exactly to the turns of the Barton's bandage of the head, and may be used to secure dressings

to the chin or scalp, or may be employed as a temporary dressing in cases of fracture or dislocation of the jaw. (Fig. 103.)

Barton's Bandage.—The initial extremity of the roller should be placed just below the occipital protuberance, and the roller should be carried obliquely upward, under and in front of the parietal eminence, across the vertex of the skull, then downward over the zygomatic arch, under the chin, and upward over the opposite zygomatic arch and over the top of the head, crossing the first turn as nearly as possible in the median line of the skull; the turns of the roller should next be carried under the parietal eminence to the point of starting. The bandage is next carried obliquely around under the occipital protuberance, and forward under the ear to the front of the chin, then back to the point from which the roller started. These figure-of-eight turns over the head and the circular turns from the occiput to the chin should be repeated, each turn exactly overlapping the preceding one, until the bandage is exhausted. (Fig. 104.) The extremity of the bandage should be secured by a pin, and pins should be introduced at the points where the turns cross each other, to give additional fixation to the bandage. To obtain additional security in the application of Barton's bandage, a turn of the bandage passing from the occiput to the forehead may be made, this turn being interposed between the turns of the bandage ordinarily applied.

FIG. 104.

Barton's bandage.

The Oblique Bandage of the Jaw.—This bandage is applied by placing the initial extremity of the roller in front of and above the left ear, if the left angle of the lower jaw is to be covered in. The bandage is then carried from left to right, making two complete turns around the head from the occiput to the forehead. When two turns have been made from the occiput to the forehead, the bandage is allowed to drop down upon the neck, and is carried forward under the right ear and under the chin to the angle of the left side of the jaw; it is next carried upward close to the edge of the orbit and obliquely over the vertex of the skull, then down behind the right ear, continuing this oblique turn under the chin to the left angle of the jaw, where it ascends in the same direction as the previous turns. Three or four of these oblique turns are made, each turn overlapping the preceding one, and passing from the edge of the orbit towards the ear, until the space is covered in; the bandage is then carried to a point just above the ear on the opposite side, and is reversed and finished with

FIG. 105.

Oblique bandage of the jaw.

one or two circular turns from the occiput to the forehead. (Fig. 105.) If the right angle of the lower jaw is to be covered in, the turns should be made in the opposite direction.

Recurrent Bandage of the Head.—In applying this bandage the initial extremity of the roller is placed upon the lower part of the forehead, and the bandage is carried twice around the head over the forehead to the occiput; when the bandage is brought back to the median line of the forehead it is reversed, and the reversed turn is held by the finger of the left hand while the roller is carried from the top of the head along the sagittal suture to a point just below the occipital protuberance; it is here reversed, and the reverse is held by an assistant while the roller is carried back to the forehead in an elliptical course; these turns, each covering in two-thirds of the preceding turn, are repeated with successive reverses at the forehead and occiput until one side of the head is completely covered in, when a circular turn is made over the forehead to the occiput to hold the reverses in place. The opposite side of the head is next covered in by elliptical reversed turns made in the same manner, turns being carried around the head from the forehead to the occiput to fix the previous turns. Pins should be applied at the forehead and the occiput at the points where the reversed turns concentrate. (Fig. 106.) The recurrent bandage of the head may be applied by making transverse turns, forming a *transverse* recurrent bandage.

Fig. 106.

Recurrent bandage of the head.

Spiral Bandage of the Finger.—In applying this bandage the initial extremity of the roller is secured by two or three turns around the wrist, and the bandage is carried obliquely across the back of the hand to the base of the finger to be covered in, and next to its tip by oblique turns; a circular turn is then made, and the finger is covered by ascending spiral or spiral reversed turns until its base is reached, from which point the bandage is carried obliquely across the back of the hand, and finished by one or two circular turns around the wrist. The extremity may be secured by a pin, or may be split into two tails, which are secured by tying. (Fig. 107.)

Spica Bandage of the Thumb.—This bandage is applied by placing the initial extremity of the roller upon the wrist and fixing it by two circular turns; the roller is then carried obliquely over the dorsal surface of the thumb to its distal extremity; a circular turn is next made, and the bandage is carried upward over the back of the thumb to the wrist, around which a circular turn should be made. Ascending figure-of-eight turns are then made around the thumb and wrist, each turn overlapping the previous one two-thirds, and each figure-of-eight turn should alternate with the circular turn about the wrist. These turns are repeated until the thumb is com-

pletely covered in with spica turns, and the bandage is completed by circular turns around the wrist. (Fig. 108.)

Spiral Reversed Bandage of the Arm.—In applying this bandage the initial extremity of the roller is placed upon the wrist and secured

Fig. 107.

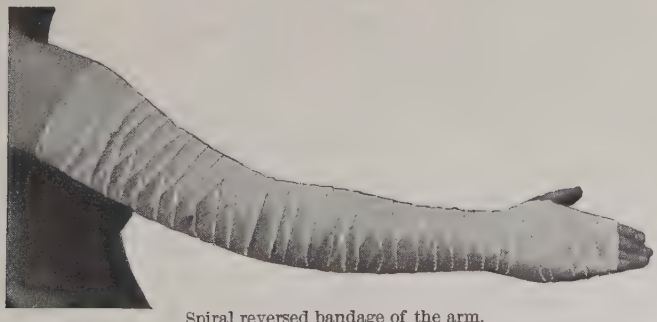
Spiral bandage of the finger.

Fig. 108.

Spica bandage of the thumb.

by two circular turns around the wrist; the bandage is then carried obliquely across the back of the hand to the second joint of the fingers, where a circular turn should be made; the hand is next covered in by

Fig. 109.



Spiral reversed bandage of the arm.

two or three ascending spiral or spiral reversed turns; when the thumb has been reached, its base and the wrist should be covered in by two figure-of-eight turns; the roller is then carried up the forearm by spiral or spiral

reversed turns until the elbow is reached, which may be covered in with spiral reversed turns or with figure-of-eight turns of the elbow. After covering in the elbow, the bandage is continued up the arm with spiral reversed turns. (Fig. 109.)

Figure-of-Eight Bandage of the Elbow.—In applying this bandage the initial extremity of the roller is placed upon the elbow, and two or three circular turns are made around the joint. The bandage is next carried to a point a little above the joint, and a circular turn is made around the arm. It is then conducted obliquely across the flexure of the joint to the upper part of the forearm, where a circular turn is made. It is next carried across the flexure of the joint, crossing the previous turn to the arm. These oblique and circular turns are repeated, descending from the arm and ascending from the forearm, until the joint is covered in. The method of applying the ascending and descending turns, the primary turns around the elbow being omitted, is shown in Fig. 110.

Fig. 110.

Figure-of-eight bandage of the elbow.

Spica Bandage of the Shoulder.—This may be applied as an ascending or a descending spica bandage. The ascending spica bandage is applied by placing the initial extremity of the roller obliquely upon the outer surface of the arm opposite the axillary fold and fixing it by one or two circular turns: if applied to the right shoulder-joint the bandage is carried across the front of the chest to the axilla of the opposite side, and is conducted around the back of the chest to the point of starting upon the arm; the roller should then be carried around the arm and up over the shoulder, across the front of the chest, through the opposite axilla, over the posterior surface of the chest to the point of starting. These ascending turns, each overlapping the preceding one about two-thirds, should be applied until the shoulder is covered in, when the extremity of the bandage should be secured by a pin at the point of ending. The turns should be made in such a manner that the spica turns shall keep as nearly as possible in the median line of the shoulder. (Fig. 111.)

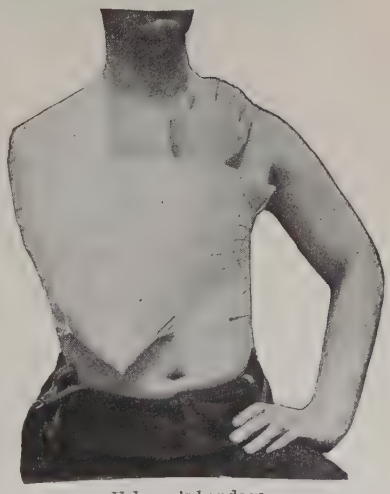
Fig. 111.

Spica bandage of the shoulder.

Velpeau's Bandage.—Before applying this bandage the patient should place the fingers of the hand of the affected side upon the opposite shoulder, the arm resting against the chest; the initial extremity of the bandage

should be placed on the body of the scapula of the sound side, and be secured by a turn made by carrying the bandage over the shoulder of the affected side, near its outer portion; it should then be continued downward over the outer and posterior surface of the arm of the same side behind the bend of the elbow, and obliquely across the front of the chest to the axilla of the opposite side, thence to the point of starting. This turn should be repeated to fix the initial extremity of the bandage; the second turn being completed, the roller should be carried transversely around the thorax, passing over the flexed elbow, and from this point to the axilla, and through this to the back; from this point the roller should be carried over the shoulder and down the outer and posterior surface of the arm behind the elbow, and obliquely across the front of the chest, through the axilla to the back, and continuing should pass transversely across the back of the chest to the elbow, which it encircles, and then be passed to the axilla. These alternating turns are repeated until the arm and forearm are bound firmly to the side and chest. The vertical turns over the shoulder, each turn covering two-thirds of the previous turn, and ascending from the point of the shoulder towards the neck, and from the posterior surface of the arm towards the elbow, are applied until the point of the elbow is reached. The transverse turns passing around the chest and arm are so applied that they ascend from the point of the elbow towards the shoulder, each turn covering in one-third of the previous one, and the last turn should pass transversely around the shoulder and chest, covering the wrist. (Fig. 112.) The extremity of the bandage should be secured by a pin, and additional fixation will be obtained by introducing a number of pins at the points where the turns of the bandage cross.

FIG. 112.



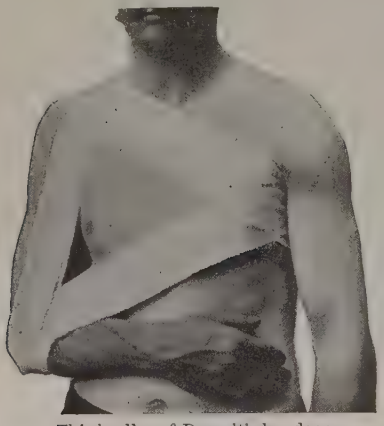
Velpeau's bandage.

Desault's Bandage.—To apply this bandage three rollers are required, as well as a wedge-shaped pad which fits in the axilla. The *first* roller of Desault's bandage secures the pad in the axilla by circular turns of the bandage around the pad and chest; the *second* roller holds the arm in contact with the pad and the side of the chest by circular turns of the bandage around the arm and chest.

Third Roller of Desault's Bandage.—In applying this roller the initial extremity of the bandage should be placed in the axilla of the sound side, and the bandage carried obliquely over the front of the chest to the shoulder of the injured side, and then pass over this and be conducted down the back of the arm to the elbow; thence obliquely upward, over the upper fifth of the forearm, to the axilla of the sound side; from this point it should be carried backward obliquely over the back of the

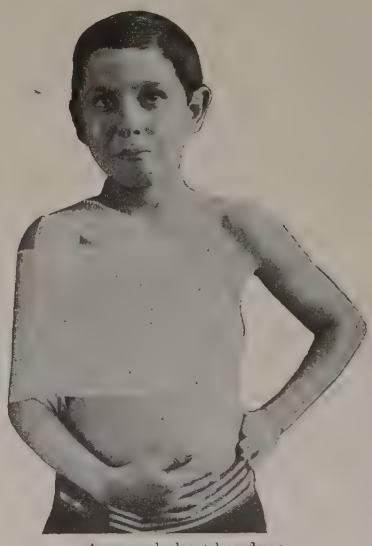
chest and the shoulder, crossing the previous shoulder turn, and then be conducted down in front of the arm to the elbow, then carried around this, and backward obliquely over the back of the chest to the axilla of the sound side; these turns overlying one another exactly should be repeated until three sets of turns have been made. (Fig. 113.) After applying the three rollers, as before described, the hand and the uncovered

Fig. 113.



Third roller of Desault's bandage.

Fig. 114.



Arm and chest bandage.

portion of the forearm should be supported in a sling suspended from the neck.

Arm and Chest Bandage.—In applying this bandage, the arm having been placed against the side, with a folded towel between the arm and the chest, the initial extremity of the bandage is placed upon the spine at a point opposite the elbow-joint, and is fixed by a turn or two passing around the arm and chest. The bandage is then continued by making ascending spiral turns covering the arm and chest until the axilla is reached. At this point the bandage is carried through the axilla and over the back of the chest to the opposite shoulder, then conducted down the front of the arm to the elbow, passed between the elbow and the body, and carried up the back of the arm to the shoulder, then conducted obliquely across the front of the chest and secured upon the back. (Fig. 114.)

Ascending Spica Bandage of the Groin.—In applying this bandage the initial extremity of the roller should be placed obliquely upon the upper part of the thigh, and the bandage should be carried around and behind the limb and forward around the outer side of the thigh to the abdomen; it should then be carried obliquely across the lower part of the abdomen to a point just below the crest of the ilium, conducted transversely around the back of the pelvis to a corresponding point upon the opposite side, and then brought obliquely downward to the groin, over the inner portion of the thigh, and carried around the limb, crossing the starting-turn in the middle line of the thigh. These turns should be

repeated, each turn ascending and covering in two-thirds of the previous turn, until five or six complete turns have been made, and the extremity should be secured at the point where it ends. (Fig. 115.)

Double Spica Bandage of the Groins.—In applying this bandage the roller should be placed on the abdomen just above the iliac crest, and secured by one or two circular turns; the bandage is then carried from a point just below the crest of the right ilium obliquely across the lower portion of the abdomen to the outer portion of the left thigh, passed around this and brought up between the scrotum and the thigh, and carried obliquely over the groin, crossing the previous turn in the median line; it should then be conducted to a point just below the crest of the ilium of the same side, and carried around the pelvis to the same point on the opposite side, and from this point it should be made to pass obliquely over the groin to the inner side of the right thigh, passing around this and coming up on

Fig. 115.

Spica bandage of the groin.

Fig. 116.

Double spica of the groins.

its outer side, crossing the previous turn at the middle line of the groin, and be carried obliquely across the groin and the lower part of the abdomen to the crest of the ilium on the opposite side. These turns should be repeated, each turn covering in two-thirds of the previous one, until both groins have been covered. (Fig. 116.)

Figure-of-Eight Bandage of the Knee.—In applying this bandage the initial extremity of the roller should be placed upon the thigh three inches above the patella, and secured by two or three circular turns; the bandage should then be conducted over the outer condyle of the femur, crossing the popliteal space, to the inner border of the tibia, and around the anterior surface below the tubercle and the head of the fibula, where a circular turn should be made; the roller should then be carried obliquely across the popliteal space to the inner condyle of the femur, crossing the previous turn, and be conducted around the front of the thigh to the outer condyle. These turns should be repeated, ascending from the leg to the thigh, and descending from the thigh to the leg, and the bandage should be finished by a circular turn over the patella. (Fig. 117.) This bandage

may also be applied by first making two or three circular turns around the knee, and afterwards applying figure-of eight turns as described above, descending from the thigh and ascending from the leg to the knee. A figure-of-eight bandage of both knees may be applied in the same manner.

Fig. 117.

Figure-of-eight bandage of the knee.

French Bandage of the Foot.—In applying this bandage the initial extremity of the roller should be fixed on the leg just above the ankle and secured by two circular turns around the leg; the bandage should be carried obliquely across the dorsum of the foot to the metatarso-phalangeal articulation, at which point a circular turn should be made around the foot; the roller should then be carried up the foot, covering it with two or three spiral reversed turns, and after this a figure-of-eight turn should be made around the ankle and instep; this should be repeated once to cover the foot, with the exception of the heel, and the bandage continued up the leg with spiral reversed turns. (Fig. 118.)

Spica Bandage of the Foot.—In applying this bandage the initial extremity of the roller should be fixed just above the ankle and secured by two circular turns; the bandage should then be carried obliquely over the dorsum of the foot to the metatarso-phalangeal articulation; a circular turn around the foot should be made at this point, and the bandage

Fig. 118.

French bandage of the foot.

Fig. 119.

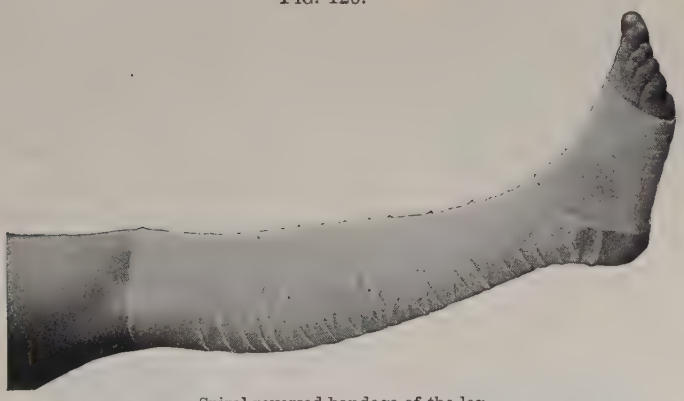
Spica bandage of the foot.

continued upward over the metatarsus by making two or three spiral reversed turns; it should then be carried parallel with the inner or the outer margin of the sole of the foot, according as it is applied to the right or the left foot, directly across the posterior surface of the heel, and from

this point it should be conducted around the outer border of the foot and over the dorsum, crossing the original turn in the median line of the foot, thus completing the first spica turn. These spica turns should be repeated, gradually ascending, by allowing each turn to cover in three-fourths of the preceding one, until the foot is covered, with the exception of the posterior portion of the sole of the heel; the turns should cross one another in the median line of the foot, and should be kept parallel throughout their course. (Fig. 119.)

Spiral Reversed Bandage of the Leg.—In applying this bandage the roller should be placed on the leg just above the ankle and secured by two circular turns; it should then be carried obliquely over the foot to the metatarso-phalangeal articulation, where a circular turn should be made around the foot; the foot should next be covered in with two or three spiral reversed turns, and two figure-of-eight turns made around the ankle and instep, and just above the ankle one or two circular or spiral turns around the leg; as the bandage is carried up the leg, spiral reversed turns

FIG. 120.



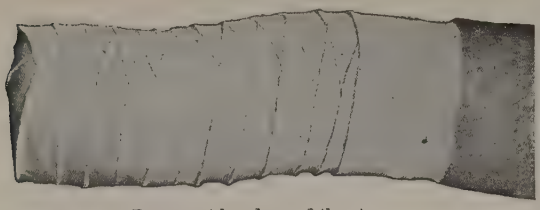
Spiral reversed bandage of the leg.

are made until it approaches the knee at this point. If the limb is to be kept straight, spiral reversed turns may be continued over this region up the thigh. If the knee is to be bent, figure-of-eight turns should be applied until the knee is covered; then the thigh can be covered in with spiral reversed turns. (Fig. 120.)

Recurrent Bandage of the Stump.—In applying this bandage the initial extremity of the roller should be placed upon the anterior or the posterior surface of the limb a few inches above the extremity of the stump, and the bandage carried over the end of the stump, and then conducted upward on the stump to a point directly opposite the point of starting; the bandage should then be brought back over the face of the stump to the point of starting, a sufficient number of these recurrent turns being made, each turn overlapping two-thirds of the previous one, until the face of the stump is covered in; the bandage should then be reversed, and the recurrent turns should be secured at their points of origin by two or three circular turns. The roller should next be carried

obliquely down to the end of the stump, and a circular turn should be made around it, and the bandage should next be carried up the limb by spiral or spiral reversed turns, and secured by two or three circular turns. (Fig. 121.) In very short stumps resulting from amputations at or near the shoulder- or hip-joint, after making the recurrent spiral turns it will be found necessary to carry the bandage in the case of the shoulder across the chest to the opposite axilla, and apply several of these turns ; and in the case of hip amputations it will be found best to finish the bandage with a few turns about the pelvis.

Fig. 121.

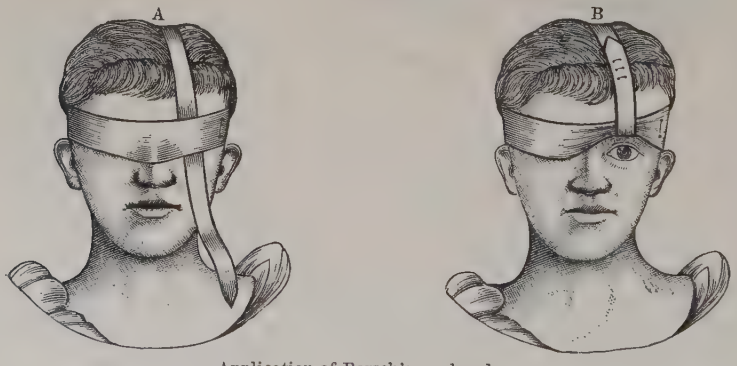


Recurrent bandage of the stump.

Liebreich's Eye Bandage.—This bandage consists of a strip of flannel from six to ten inches in length and two and a half inches in width, to the extremities of which are sewed tapes. It may be applied obliquely, so as to cover one eye only, or transversely, so as to cover both eyes, and it is secured by tapes carried around the head and tied over the forehead. The elasticity of the flannel permits of its being applied so as to exert a variable amount of pressure. It is used to hold compresses or dressings to the eye or eyes.

Borsch's Eye Bandage.—This is a convenient bandage for holding a dressing to one eye, and consists of a horizontal strip of flannel two and a half inches in width, which is passed around the head from the occiput and covers the eyes ; to this is attached a narrow strip of flannel at the posterior

Fig. 122.



Application of Borsch's eye bandage.

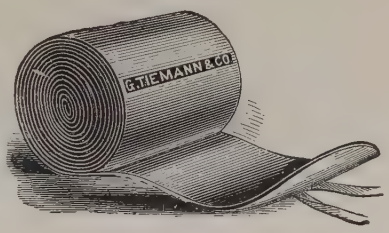
portion, which is carried over the head and passed under the horizontal strip in front of the eye which is to be left uncovered, and is then folded back so as to raise the horizontal strip from the eye, and secured. (Fig. 122.)

Flannel Bandages.—These are prepared from flannel cut into strips from two to four inches in width and from five to seven yards in length, which are formed into rollers. By reason of the elasticity which they

possess these bandages can be applied without reverses. They are often employed in applying dressings to the head, especially after operations upon the eyes, and as the primary roller before the application of the plaster of Paris dressing. They may also be used in subacute joint affections, both to protect the part and to make a moderate amount of elastic pressure.

The Rubber Bandage.—This bandage is made from a strip of rubber sheeting from one inch to four inches in width and from three to five yards in length, which for convenience of application is rolled into a cylinder. It is used where it is desirable to apply elastic pressure to a part, and is often employed in the treatment of varicose veins of the leg and of chronic ulcers, where pressure is an important element in the treatment. The rubber bandage for application to the leg should be two and a half inches in width and three yards in length (Fig. 123), and is applied as follows: the initial extremity of the roller should be placed on the foot near the toes, and secured by a circular turn; the foot and ankle should be covered in by spiral turns which overlap one another about two-thirds, and the bandage should then be carried up to the knee by spiral turns, at which point it should be secured by tapes sewed to the terminal extremity of the bandage, which are passed around the leg and tied. Reverses are not necessary in its application, as its elasticity allows it to conform to the shape of the limb. In applying the bandage it should be stretched very slightly; if this precaution is not taken it soon becomes uncomfortable to the patient. The patient using one of these bandages will soon learn to apply it himself, making just the requisite amount of tension to secure its holding its place and to assure a comfortable amount of pressure upon the part. A well-fitting stocking may be placed upon the limb before the bandage is applied, or it may be applied directly to the skin. In applying this bandage in the treatment of ulcers no ointment should be used, as oily dressings soon destroy the rubber. Dry powders, such as oxide of zinc, iodoform, or aristol, should be dusted upon the ulcer before the bandage is applied. The bandage should be removed at night when the patient goes to bed and hung up to dry, as its inner surface becomes moist from secretions from the skin, and it should be reapplied as soon as the patient rises in the morning.

Fig. 123.



Rubber bandage.

FIXED DRESSINGS OR HARDENING BANDAGES.

In applying these dressings many substances are used, which are incorporated in the meshes of some fabric, such as crinoline or cheese-cloth, or are painted over its surface to give fixity or solidity to the dressing. The materials generally used in the application of fixed dressings are *plaster of Paris*, *starch*, *silicate of sodium*, or *silicate of potassium*. The plaster of Paris used for the preparation of surgical dressings should be of the same quality as that which dental surgeons employ in taking casts for teeth—that is, the

extra-calcined variety, which sets in a few minutes; if moist, or of inferior quality, it will not set rapidly or firmly and will fail to give sufficient fixation to the dressing.

The most convenient method of applying the plaster of Paris dressing is by means of bandages impregnated with plaster of Paris, which are prepared as follows: cheese-cloth, mosquito-netting, or crinoline—the latter is by far the best fabric—is cut or torn into strips from two and a half to four or five inches in width and five yards in length; these are laid upon a table, and plaster of Paris is dusted over them and rubbed into the meshes of the fabric; the material when impregnated with the plaster is loosely rolled into a cylinder, or the bandages may be prepared by a machine made for this purpose, which distributes the plaster through the meshes of the fabric. Plaster of Paris bandages should be freshly prepared, or if they are to be kept for any time they should be placed in air-tight jars or cans. Bandages which have been exposed to the air or have been kept for a long time are not apt to set well when applied; however, if such bandages are placed in a hot oven and baked for half an hour, they will be found to set as satisfactorily as those freshly made.

Application of the Plaster of Paris Bandage.—Before applying this dressing the part to be encased should be covered by a flannel roller, and bony prominences should be protected by pads of cotton. In applying this dressing to the leg, for instance, a flannel bandage or closely fitting stocking may be used to cover the part. The bandage is prepared for application by soaking it in warm water for a few moments, and as soon as bubbles of air cease to escape it is an indication that it is thoroughly

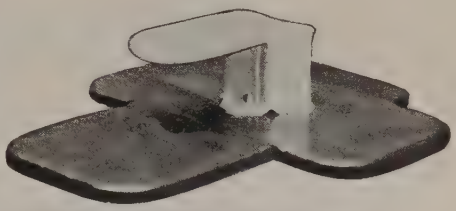
FIG. 124.

Plaster of Paris bandage of the leg.

soaked, and is ready for use. Upon removing the bandage from the water, the excess of water should be squeezed out by the hands; the bandage should then be evenly applied to the limb without reverses, and with just enough firmness to make it fit the part neatly. Only so many bandages should be applied as will make a firm dressing—three rollers of the above dimensions being usually ample for a dressing for the leg—and when the last roller has been applied some dry plaster should be mixed with water

until it has the consistency of thick cream, and this should be rubbed evenly over the surface of the bandage to give it a finish. (Fig. 124.) If a good quality of plaster has been used, the bandage should be quite firm in from ten to fifteen minutes; but the patient should not be allowed to put any weight on it for several hours. An equally firm dressing may be secured by the use of a lesser number of bandages if the surface of each layer of bandage is rubbed over with a little moist plaster of Paris, and this procedure is repeated for each layer of bandage. A firm plaster of Paris dressing may also be applied by the use of very few bandages if narrow strips of tin, zinc, or binder's board be incorporated in the layers of the bandage. In applying the plaster of Paris bandage to the upper part of the thigh and pelvis, the use of a pelvic support, shown in Figs. 125 and 126, will be found most satisfactory.

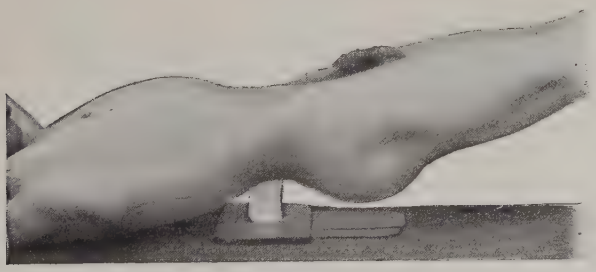
Fig. 125.



Pelvic support for applying plaster of Paris to the pelvis and thigh. (Dr. H. Reed.)

Interrupted Plaster of Paris Dressing.—This form of plaster of Paris dressing is applied by first covering the limb with a flannel roller up to the lower limit of the part which is to be left exposed, and then applying the flannel roller from the upper limit of the part, which is to be exposed as far as may be desired to apply the plaster of Paris. A few turns of the plaster of Paris bandage are next made around the lower portion of the limb, covering in the part included in the flannel roller.

Fig. 126.

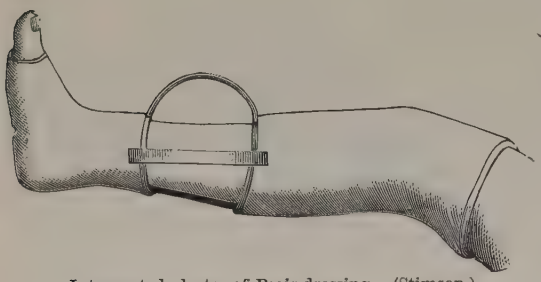


Support in place for application of plaster of Paris.

The plaster of Paris roller is next applied above the exposed region, and is carried up the limb as far as desired. A short iron rod is then placed under the extremity, extending some distance above and below the point at which the dressing is to be interrupted, and this is fixed in place by a few turns of plaster bandage above and below the portion of the limb which is to be left exposed. Three pieces of stout wire are next bent into loops, the extremities of which are incorporated in the subsequent turns of the plaster of Paris bandage; a number of turns of the bandage are applied to fix the loops firmly, and the limb is held in the desired position until the plaster sets. (Fig. 127.)

Moulded Plaster Splints.—The application of the ordinary plaster dressings to parts irregular in shape is often difficult, and it is sometimes desirable to have a splint which can be removed with ease. These indications are best met by the application of moulded plaster splints, which may be made by cutting a paper pattern of the part to be covered in and then cutting pieces of crinoline to conform to this pattern; eight or ten pieces will usually form a splint of sufficient thickness. One of these pieces of crinoline is laid upon a table and dry plaster is rubbed into its meshes, another is laid upon this and plaster is applied to it in the same way, and so on until all the pieces have been placed in position, one over the other, with plaster rubbed into their meshes. The dressing is then folded up, dipped in water, squeezed out, and moulded to the part, and held in position by the turns of a bandage. The edges should slightly overlap, and in applying the dressing a strip of waxed paper should be placed under the overlapping edge to prevent its adhesion to the dressing below, and thus facilitate its removal.

Fig. 127.



Interrupted plaster of Paris dressing. (Stimson.)

Fenestrated Plaster Dressing.—When a plaster of Paris dressing is applied to a part where there is a wound, it is well to make some provision whereby the plaster dressing over the site of the wound can be cut away, making a trap or window through which the wound can be inspected or dressed if necessary. To accomplish this, before applying the plaster a compress of lint or gauze should be placed over the wound, which when the dressing is completed forms a projection upon its surface, indicating the position of the wound, and which also allows the surgeon to cut away the dressing without injuring the skin below. These traps may be cut out after the bandage is partially set, or after it has become hard.

Removal of Plaster of Paris from the Hands.—The difficulty of removing plaster of Paris from the hands of the surgeon is one objection to the use of the plaster dressings, as is also the harsh condition in which the skin of the hands is left after its removal. This objection may be readily overcome if the hands are washed in a solution of carbonate of sodium (washing soda), a tablespoonful to a basin of water, which will readily remove the plaster and leave the skin in a comfortable condition.

Removal of the Plaster of Paris Bandage.—This is sometimes a matter of difficulty, and may be a source of discomfort to the patient if it has to be done before the parts below are consolidated. When the plaster bandage is applied to obtain a cast of the part, or when its removal will probably be necessary in a few days, a strip of sheet-lead half an inch in width is placed over the flannel bandage so that it will project at each end beyond the plaster dressing when applied. The plaster bandage is then applied, and when it is partially set it can be readily cut through upon this

strip with a knife without injury to the parts below. (Fig. 128.) It may also be removed by means of a saw devised for this purpose (Fig. 129) or by strong cutting shears. (Fig. 130.) If the bandage has not been cut directly after its application, as previously described, the most satisfactory

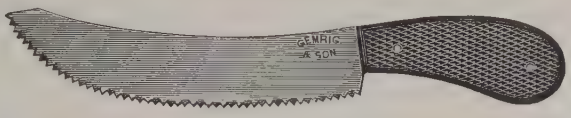
Fig. 128.

Cutting plaster bandage on lead strip.

method of removing it is by the use of the saw or shears; care should be exercised in using them, as the final layers of the bandage are divided, to avoid injuring the skin.

The Starched Bandage.—The starched bandage is prepared by first mixing the starch with cold water until a thick creamy mixture results;

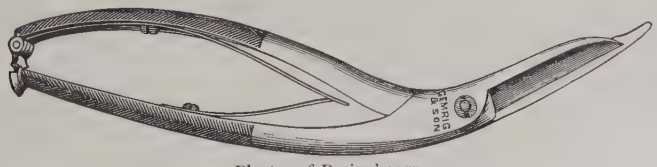
Fig. 129.



Plaster of Paris saw.

this may be heated, or may have added to it boiling water, until a clear mucilaginous mass is produced. The part to which the dressing is to be applied is first covered with a flannel roller, and over this a few layers of cheese-cloth or crinoline bandage which has been shrunken are applied; the

Fig. 130.



Plaster of Paris shears.

starch is then smeared or rubbed with the hand evenly into the meshes of the material, and the part is covered with another layer of turns of the bandage, and the starch is again applied. This manipulation is continued

until a dressing of the desired thickness is produced. It usually requires from twenty-four to thirty-six hours for the starched bandage to become dry and thoroughly set. The starched bandage may be employed for the same purposes as the plaster of Paris bandage, and is often available when the plaster of Paris bandage cannot be obtained. Starched bandages are removed in the same way as the plaster bandages.

Silicate of Potassium or Sodium Bandage.—This bandage is applied by first covering the part with a flannel roller and several layers of cheese-cloth or crinoline bandage; the surface of the latter is then covered with silicate of sodium or of potassium, applied by means of a brush; then a second layer of bandage is applied and painted over in the same manner with the silicate of sodium or of potassium, and this manipulation is continued until a dressing of the desired thickness is produced. It usually requires twenty-four hours for this dressing to become firm, but we have found that by covering the silicate bandage with a layer of tissue-paper and then applying a light plaster of Paris bandage, fixation of the parts is made secure after the setting of the plaster of Paris bandage, and this may be removed in twenty-four hours, when the silicate bandage will be found perfectly hard. The silicate bandage may be removed with saw or shears, or may be softened by soaking in warm water, when it can be readily cut through with scissors.

Raw-Hide or Leather Splints.—Splints prepared from raw hide or leather are often used in the treatment of fractures or for fixation dressings.

Fig. 131.

Binder's board splint for leg and foot.

In preparing these splints of raw hide or leather, it is necessary to apply a plaster of Paris bandage to the part to which the raw-hide splint is to be fitted, and as soon as the plaster has set it is removed; a solid plaster cast is next made by greasing the inner surface of the mould and pouring in liquid plaster of Paris. When this has become dry, a piece of raw hide which has been soaked for several days in water is moulded to the cast and held firmly in contact with it by a bandage or by means of tacks until it has become perfectly dry, which often requires a number of days. It should then be removed, and its surface covered with several coats of shellac to prevent its absorbing moisture from the skin and changing its shape when applied. Eyelets or hooks are fastened to the edges of the splint, through which strings are passed to secure it in place.

Binder's Board Splints.—Binder's board, which may be obtained in sheets of different thicknesses, is frequently employed for the manufacture of splints. In moulding these splints a portion of the board of the requisite size and thickness is dipped into boiling water for a short time, and when it has become softened it is removed and allowed to cool. A thick layer of cotton batting is next applied over it, and it is

then moulded to the part and held firmly in position by the turns of a roller bandage; in a short time it becomes dry and hard. (Fig. 131.)

Porous Felt Splints.—This material also is employed for the manufacture of splints, and is applied by dipping it in hot water and moulding it to the part; as it dries it becomes hard.

PLASTERS.

The varieties of plasters which are most commonly employed in surgical dressings are *adhesive* or *resin* plaster, *isinglass* plaster, *rubber adhesive* plaster, and *soap* plaster. Before using plasters, if the part to which they are to be applied is covered by hairs, these should be removed by shaving, otherwise traction upon them, if the plaster is used for the purpose of extension, will give the patient discomfort or pain. If this precaution has been neglected, the final removal of the plaster also will cause severe pain.

Resin Plaster.—This plaster is widely employed in surgical dressings. It is cut into strips of the required width and length, and is heated before being applied to the surface by applying the unspread side to a vessel containing hot water, or by passing it rapidly through the flame of an alcohol lamp. This variety of plaster is generally used in making the extension apparatus for the treatment of fractures, for strapping the chest in fractures of the ribs and sternum, and for strapping the testicle, ulcers, or joints.

Isinglass Plaster.—This plaster is made by spreading a solution of isinglass upon silk or muslin, and is frequently employed in the dressing of superficial wounds. It is made to adhere to the surface by moistening it.

Rubber Adhesive Plaster.—This plaster is made by spreading a preparation of india-rubber on muslin, and has the advantage over ordinary resin plaster that it adheres without the application of heat. When applied continuously to the skin for some time it is apt to produce a certain amount of irritation. It is employed for the same purposes as resin plaster.

Soap Plaster.—Soap plaster for surgical purposes is prepared by spreading *Emplastrum Saponis* upon kid or chamois. It is not used for the same purposes as the resin or the rubber plaster, as it has little adhesive power, but is employed simply to give support to parts or to protect salient portions of the skeleton from pressure. It constitutes a useful dressing when applied over the sacrum in cases of threatened bed-sores, and may be employed with advantage to protect bony prominences which are subjected to splint pressure in the treatment of fractures. In the treatment of sprains of joints a well-moulded soap plaster splint secured by a bandage will often be found a most efficient dressing.

STRAPPING.

The application of strips of plaster to produce pressure or fixation is often resorted to in surgical practice.

Strapping the Testicle.—In strapping the testicle strips of resin plaster are usually employed, half an inch in width and twelve inches in length. The scrotum should be washed and shaved, and the surgeon then draws the skin over the affected organ tense by passing the thumb and

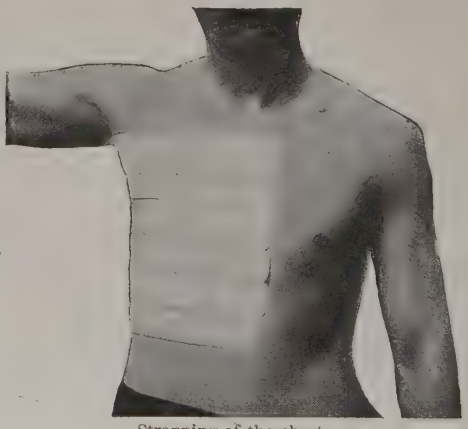
finger around the scrotum at its upper portion; a strip of plaster which has been heated is passed in a circular manner above the organ and is tightly drawn and secured; this isolates the testicle and prevents the other strips from slipping; strips are next applied in a longitudinal direction, the first strip being fastened to the circular strip and carried over the most prominent part of the testicle, and then back to the circular strip and fastened. A number of these strips are applied in an imbricated manner until the skin is covered (Fig. 132), and the dressing is completed by passing transverse strips around the testicle from its lowest portion to the circular strip, care being taken that no portion of the skin is left uncovered.

Fig. 132.

Strapping the testicle. (Bryant.)

Strapping the Chest.—In strapping one half of the chest strips of resin plaster, two and a half inches in width, from eighteen to twenty inches in length, and long enough to extend from the spine to the median line of the sternum, are required. The first strip is heated, and one extremity is placed upon the spine opposite the lower portion of the chest; it is then carried around the chest, and its other extremity is fixed upon the skin in the median line of the sternum. Successive strips are applied from below upward in the same manner, each strip overlapping one-third of the preceding one, until the axillary fold is reached. (Fig. 133.) A second layer of strips may be applied over the first if additional fixation is desired, or a few oblique strips may be employed. Strapping materially limits the motion of the chest-wall, and constitutes a useful dressing in the treatment of fractures and dislocations of the ribs and contusions of the chest.

Fig. 133.



Strapping of the chest.

Strapping of Ulcers.—Strapping is frequently employed in the treatment of ulcers of the leg. To strap an ulcer of the leg, strips of resin plaster one and a half inches in width and long enough to extend two-thirds around the limb are required. The ulcer should be thoroughly cleansed and the skin surrounding it well dried; the first strip being heated, it is applied transversely or obliquely to the long axis of the leg, about two inches below the ulcer, and is carried two-thirds around the limb; the next strip covers in about one-third of the previously applied strip, and a sufficient number of strips are applied to cover the ulcer and extend several inches beyond it. Care should be taken that the strips are so placed as not to cover the entire circumference of the limb, as injurious circular compres-

sion may result. This dressing is usually reinforced by the application of a firmly applied spiral reversed or spica bandage of the leg. Strapping of ulcers may also be accomplished by using two strips which are fastened to the skin at some distance from the edges of the ulcer; traction is made upon them, and they are made to cross obliquely over the ulcer; additional strips are applied in this manner until the surface of the ulcer is covered. The strapping of chronic ulcers of the leg will be found a most satisfactory dressing in patients who have to work during the course of treatment, the strips requiring removal only at intervals of a week, and if well applied the dressing is generally a comfortable one to the patient.

Strapping of Joints.—In strapping joints, strips of resin or rubber adhesive plaster, from one to one and a half inches in width and long enough to extend two-thirds around the joint, are required. The first strip is applied a few inches below the joint, and strips are then applied over this, each strip covering in two-thirds of the preceding one, until the joint is covered in and the dressing extends a few inches above it. Strapping of joints will be found a satisfactory dressing in the treatment of sprains of joints in their acute or chronic stages.

POULTICES.

This form of application was formerly much used in the treatment of inflammatory conditions and injuries, and, although it is seldom employed since the introduction of the antiseptic method of wound treatment, we think there are still conditions in which its employment is both useful and judicious. Poultices may be used with advantage in deep-seated inflammatory affections of the fascia and bone, combined with rest, and often relieve the pain by producing relaxation of the tissues. Their previous use does not prevent the surgeon from employing all aseptic precautions if operative treatment is subsequently required.

Flaxseed Poultice.—This poultice is prepared by mixing a little cold water with ground flaxseed and then adding boiling water and stirring it until the resulting mixture is of the consistency of thick mush. A piece of muslin, a little larger than the intended poultice, is laid upon the surface of a table and the poultice mass is spread evenly upon it with a spatula or knife, to the thickness of from one-fourth to one-half inch; a margin of the muslin of one or one and a half inches is left, which is turned over after the poultice is spread, and serves to prevent its escape around the edges when applied. After being applied to the surface of the skin it is covered with a piece of oiled silk, rubber tissue, or waxed paper, and is held in position by a bandage or a binder.

Charcoal Poultice.—This poultice is prepared by mixing flaxseed-meal and powdered animal charcoal in equal parts and adding boiling water until a poultice mass is produced, which is spread upon muslin as previously described.

Fermenting Poultice.—This poultice is prepared by adding two tablespoonfuls of yeast to a mixture of flaxseed with hot water, making a thin poultice mass, which is allowed to stand for a few hours in a warm place, when it ferments and becomes light; it is then spread upon muslin

and applied as required. A piece of yeast-cake or a few ounces of porter may be used as a substitute for yeast in preparing the fermenting poultice. Animal charcoal may be added to increase its disinfecting power.

Oakum or Cotton Poultice.—This form of poultice is prepared by soaking a mass of loosely picked oakum or absorbent cotton in hot water, wringing it out, and covering it with a layer of cheese-cloth or antiseptic gauze. After applying it to the surface of the body it should be covered with oiled silk or rubber tissue. These materials may be wrung out of warm carbolic or bichloride solution, and thus form an *antiseptic poultice.*

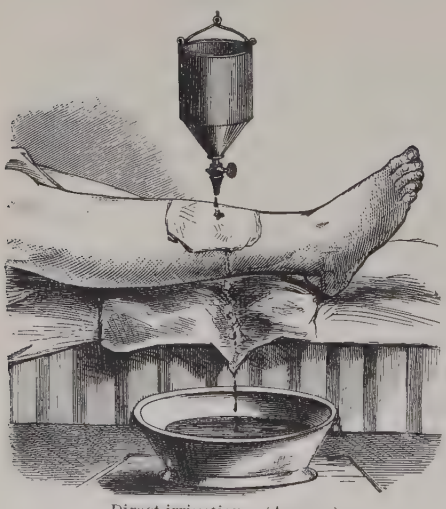
Soap Poultice.—This is prepared by mixing one part of green soap with four parts of water; pads of gauze are then soaked in this mixture and applied to the part. Soap poultices thus made are often applied for some hours to a part as a preparatory step in its sterilization, and are especially useful where there is much thickening of the epidermis.

Hot Fomentations.—Hot fomentations may be employed to combat inflammatory action, or to keep up the vitality of parts which have been subjected to severe injury. They are applied by means of pads of gauze, old muslin, surgical lint, or flannel cloths, which are soaked in water having a temperature of 120° F. (40.5° C.); these are wrung out and placed upon the part and covered with waxed paper or rubber tissue; a second pad should be ready to apply as soon as the first begins to cool, and so by continuously reapplying them the part is kept constantly covered with a hot, moist dressing.

IRRIGATION.

Irrigation may be accomplished by allowing the irrigating fluid to run over a wound or an inflamed part, or by permitting the cold or warm fluids to pass through rubber tubes which are in contact with or surround the part: the former method is known as *direct* or *immediate* irrigation, the latter as *mediate* irrigation.

Fig. 134.



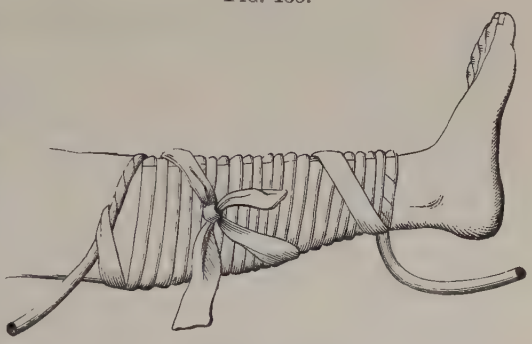
Direct irrigation. (Agnew.)

Direct Irrigation.—In employing direct irrigation in the treatment of wounds or inflammatory conditions, a funnel-shaped can or glass jar with a stopcock at the bottom, or a rubber bag, is suspended over the part at a distance of a few inches (Fig. 134); the can or bag is filled with water, and this is allowed to fall drop by drop upon the part to be irrigated, which should be placed upon a piece of rubber sheeting so arranged as to permit the water to run off into a receptacle and prevent the wetting of the patient's bed. The water employed may be either cold or warm, according to the indications in special cases. If it is desirable to make use of antiseptic irrigation, the water is impregnated with carbolic

acid or bichloride of mercury; a 1 to 60 to 80 carbolic acid solution or a 1 to 4000 to 8000 bichloride solution is frequently employed with good results.

Mediate Irrigation.—In this method a flexible tube of india-rubber, half an inch in diameter and from sixteen to twenty feet in length, with thin walls, is applied to the limb like a spiral bandage, or is applied in a coil to the head, breast, or joints, and held in place by a few turns of a bandage. The end of the tube is attached to a reservoir filled with cold or warm water above the level of the patient's bed, and the water is allowed to flow constantly through the tube, whence it escapes into the receptacle arranged to receive it. (Fig. 135.)

Fig. 135.



Mediate irrigation.

Cold Water Dressings.—These dressings are applied by bringing water, whose temperature may vary from that of cool water to that of ice-water, directly in contact with the part, or by applying it by means of a rubber bag or bladder. Cold water dressings are employed in local inflammatory conditions, and a popular method of application is by means of *cold compresses*, which are made of a few layers of surgical lint dipped in water of the desired temperature and applied to the part; they should be renewed as they become warm. If it is desirable to have the compresses very cold, they may be laid upon a block of ice or in a basin with broken ice. The *ice-bag*, which consists of a rubber bag or bladder filled with broken ice, is used to obtain the direct action of cold upon the part. It is often employed as an application to the head in inflammatory conditions of the brain or its membranes, and it is also used upon the surface of the body to control internal hemorrhage.

COUNTER-IRRITATION.

This consists in producing external irritation to influence internal morbid processes, the results obtained being due to the action of the irritant upon the blood-vessels and nerves.

Counter-irritants are substances employed to excite external irritation. The extent of their action varies with the material used and the duration of its application: superficial redness or the complete destruction of the vitality of the parts to which they are applied may result. They are widely used as local revulsants in cases of congestion or inflammation, and have a stimulating effect in cases of collapse.

Hot Water.—When it is desired to make a quick impression upon the skin, the application of muslin or flannel cloths wrung out of hot water and renewed frequently will produce a superficial redness of the integument.

Spirit of Turpentine.—This drug when applied to the skin is a very active counter-irritant. Its action may be obtained by rubbing it directly upon the surface of the skin, when marked redness results, or when less decided action is desired it may be combined with equal parts of olive oil before it is applied. The *turpentine stupe*, which is prepared by sprinkling spirit of turpentine over flannel cloths which have been wrung out of hot water, or by dipping them in warm spirit of turpentine, and applying them to the surface of the body, is a method frequently employed to obtain the rubefacient action of spirit of turpentine. Chloroform, mustard, capsicum, and aqua ammoniæ may also be applied for their rubefacient action.

Vesicants.—Vesicants are substances which by their action on the skin cause an effusion of serum or of serum and lymph beneath the cuticle, giving rise to vesicles or blisters. The substance most commonly employed to produce vesication is cantharis, or Spanish fly, which is used in the form either of *ceratum cantharidis*, which is spread upon adhesive plaster, leaving a margin of half an inch in width uncovered, which will adhere to the skin, or of *cantharidal collodion*, several layers of which are painted upon the surface and produce vesication. Aqua ammoniæ, chloroform, and nitrate of silver may also be applied so as to produce vesication. Caution should be exercised in applying counter-irritants to patients who are comatose or under the influence of a narcotic, for here the sensations of the patients cannot be used as a guide to their removal, and their too long continued application may result in extensive destruction of the tissues. They are also contra-indicated in patients in whom the vitality of the tissues is depressed by adynamic diseases, and in aged persons.

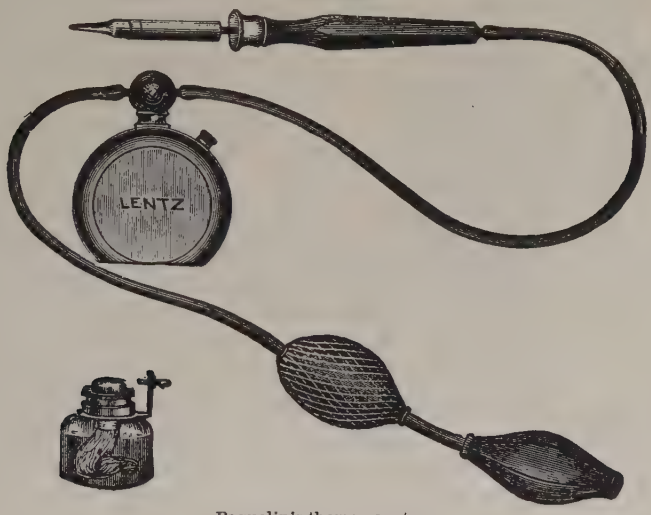
Actual Cautery.—This constitutes one of the most powerful means of counter-irritation and revulsion. Counter-irritation by this method is accomplished by bringing in contact with the skin some metallic substance brought to a high degree of temperature. The cautery-irons generally employed have their extremities fashioned in a variety of shapes, and are fixed in handles of wood or other non-conducting material. The irons are heated by placing the extremities in an ordinary fire, or by holding them in the flame of an alcohol lamp, and they should be used at a black or dull red heat. The intense pain which follows the use of the cautery may be allayed by placing upon the cautery marks compresses wrung out of ice-water or saturated with equal parts of lime water and sweet oil. If the ordinary cautery-irons are not at hand, a knitting-needle or iron poker, heated in the flame of a spirit-lamp or in a fire, may be employed with equally satisfactory results.

When it is necessary to make a deep burn by the use of the cautery-iron, the pain of its application may be allayed by the injection of a few drops of cocaine solution, or by placing a mixture of salt and cracked ice on the spot to be cauterized for a few minutes immediately before its application. Cautery-irons should not be placed over the skin covering the salient parts of the skeleton or over important organs. Actual cautery is often employed to control hemorrhage or to destroy morbid growths.

Paquelin's Thermo-Cautery.—This is a convenient and efficient means of applying cauterization, which utilizes the property of a heated

platinum sponge to become incandescent when exposed to the action of vapor of benzene or rhigolene. This form of cautery may be used at a white heat or at a dull red heat: its great advantage consists in the ease with which it can be prepared for use. (Fig. 136.) This instrument may be used to produce counter-irritation, as well as in operations upon vascular tumors

FIG. 136.



Paquelin's thermo-cautery.

where the use of a knife would be accompanied by profuse hemorrhage, or for controlling hemorrhage in cases where the ligature cannot be satisfactorily employed. Wounds made by the actual cautery are aseptic wounds, and when dusted with iodoform they generally heal promptly under the scab without suppuration.

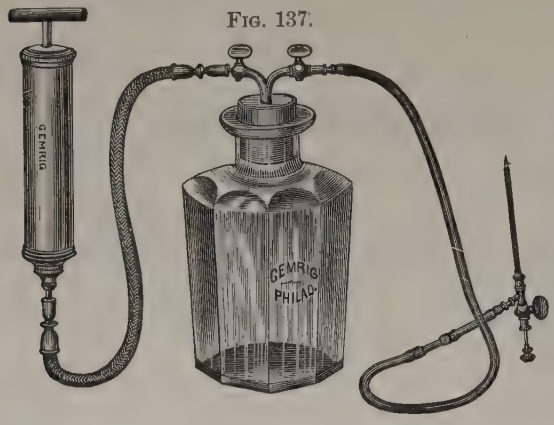
Galvano-Cautery.—This form of cautery is often employed for the same purpose as the actual cautery, but is more convenient for application in the various cavities of the body, as the electrodes, which are made of various shapes and sizes, can be introduced into the cavities while cold and quickly heated to a red or white heat. It is frequently employed for the destruction of morbid growths in the nasal passages, the throat, the vagina, or the uterus, and its employment in these cases may be rendered practically painless by previously thoroughly cocainizing the parts.

ASPIRATION.

This procedure is adopted to remove fluids from a closed cavity without the admission of air, and the instrument employed is known as an *aspirator*. Potain's aspirator (Fig. 137) is the one most convenient for use. In using this aspirator the bottle is exhausted of air by using an air-pump; the canula enclosing the trocar is next pushed through the tissues into the cavity containing the fluid to be removed; the trocar is withdrawn, and upon opening the stopcock, fluid is forced out of the cavity by atmospheric pressure and passes into the bottle or receiver. Great care should be exercised that the trocar and canula are thoroughly sterilized before being used, by being placed

in boiling water or allowed to remain for a short time in a five per cent. carbolic solution. The pain produced in introducing the trocar and canula may be diminished by holding in contact with the part which is to be punctured, for a few minutes, a piece of ice wrapped in a towel, or by the subcutaneous injection of a few drops of cocaine. After removing the canula, the small puncture remaining should be dressed with a compress of antiseptic or iodoform gauze, held in place by a bandage or an adhesive strip.

Fig. 137.



Aspirator.

The aspirator is used to ascertain the character of the contents of deep-seated tumors containing fluid, and is also employed in cases of hydrothorax, empyema, or ascites, to evacuate the contents of tuberculous abscesses in diseases of the hip and spine, and sometimes to relieve a distended bladder until a more radical operation can be performed.

MASSAGE.

This consists in a variety of manipulations, such as pinching up the integuments or muscles and rolling them between the thumb and fingers, and stroking or rubbing the surface with the palm of the hand from the periphery towards the centre, to empty the distended veins and lymphatics. Massage may also be practised by rubbing the parts circularly, or by kneading them, or by tapping the surface of the affected part with more or less force with the tips of the fingers held in a row, or with the ulnar border or the palm of the hand. If the part upon which these manipulations are to be practised contains a heavy growth of hair, this should be carefully removed by shaving, otherwise the manipulations are apt to give the patient pain, and abscesses may result from irritation and infection of the hair-follicles. The parts should also be rubbed over with olive oil, vaseline, or cacao butter before and during the manipulations. Massage will be found of great service in the later treatment of fractures involving the joints or in their vicinity, in restoring the motion of the parts, as well as improving the nutrition of muscles which have become wasted from disuse.

Passive Motion.—This manipulation consists in alternately flexing and extending or rotating the limb to imitate the normal joint movements. The manipulations should be carefully practised, and in cases of fracture should not be undertaken until there is union at the seat of fracture. Massage may often be employed in conjunction with passive motion for the treatment of the troublesome stiffness in joints resulting from fractures, dislocations, or sprains.

BLOODLETTING.

Bloodletting is often employed to obtain both the local and the general effects following the withdrawal of blood from the circulation. Local depletion is accomplished by means of scarification, cupping, and leeching, while general depletion is effected by means of venesection.

Scarification.—Scarification consists in making numerous small parallel incisions with a sharp-pointed knife, which should correspond with the long axis of the part, and care should be taken in making them to avoid wounding superficial veins and nerves. Incisions thus made relieve tension by allowing blood and serum to escape from the engorged capillaries of the infiltrated tissue of the part. Scarification is employed with advantage in inflammatory conditions of the skin and subcutaneous cellular tissue, and in acute inflammatory swelling or œdema of the mucous membrane. A modification of scarification, known as *deep incisions*, is practised in urinary infiltration, to establish drainage and relieve the tissues of the contained urine, and to prevent sloughing. In phlegmonous erysipelas and in threatened gangrene the same procedure is often adopted to relieve tension or to facilitate the escape of blood and serum. Warm fomentations applied over the incisions will increase and keep up the flow of blood and serum.

Cupping.—Cupping is a convenient method of employing local depletion by inviting the blood from the deeper parts to the surface of the skin, and may be accomplished by the use of dry or wet cups.

Dry Cupping.—Dry cups, as ordinarily applied, consist of small cup-shaped glasses which have a valve and stopcock at their summit. The cup is placed upon the skin, and an air-pump is attached, and as the air is exhausted the congested integument is seen to bulge into its cavity. (Fig. 138.) When the exhaustion is complete the stopcock is turned and the air-pump is removed, the cup being allowed to remain in position for a few minutes. This procedure is repeated until a sufficient number of cups has been applied. In cases of emergency, where the ordinary cupping-glasses and air-pump cannot be employed, a very satisfactory substitute may be obtained by burning a little paper or alcohol in a wineglass, and, before the flame is extinguished, rapidly inverting it upon the skin.

Fig. 138.

Cupping-glass.

Wet Cupping.—When the abstraction of blood as well as the derivative action is desired, wet cups are resorted to. Before applying wet cups the skin, as well as the scarificator, should be carefully sterilized. A dry cup should first be applied, to produce superficial congestion of the skin. This is removed and the scarificator is applied; and, when the skin has been cut by springing the blades, the cup is immediately applied and exhausted, and is kept in place as long as the blood continues to flow. A sharp-pointed bistoury which has been sterilized may be employed to make a few incisions in the skin instead of the scarificator, and the improvised cups may be employed if the ordinary cupping apparatus cannot be obtained. After the removal of wet cups the wounds should be

thoroughly washed with a bichloride or carbolic solution, and a gauze dressing applied.

Leeching.—In the removal of blood by leeching two varieties of leech are used,—the *American* leech, which draws about a teaspoonful of blood, and the *Swedish* leech, which draws three or four teaspoonfuls. Before applying leeches to the skin it should be carefully washed with soap and water, and the leech should be applied on the part from which the blood is to be drawn, and confined to this place by inverting a tumbler or glass jar over it; if it does not take hold, a little milk or blood should be smeared upon the surface, which will generally secure the desired result. When the leech has ceased to draw blood it is apt to let go its hold and fall off; if, however, it is desirable to remove leeches, they may be made to let go their hold by sprinkling them with a little salt. After the removal of leeches bleeding from the bites may be encouraged by the application of warm fomentations. It sometimes happens, however, that *free bleeding* continues from leech-bites after the removal of the leeches. If this cannot be controlled by the application of a compress, the bleeding point should be touched with the point of a steel knitting-needle heated to a dull red heat; and if this fails to control the bleeding, a delicate harelip-pin should be passed through the skin under the bite, and a twisted suture thrown around this. Leech-bites should be washed with bichloride or carbolic solution and dressed with a compress of bichloride gauze. Leeches should not be employed directly over inflamed tissues, but should be applied to the surrounding area; they should not be allowed to take hold directly over a superficial artery, vein, or nerve, and should never be applied to a part where there is delicate skin or a large amount of loose cellular tissue, as the eyelid or the scrotum, since unsightly ecchymoses are apt to result.

Fig. 139.

Veins at bend of elbow. (Garretson.)

Venesection.—Venesection is an operation by which general depletion or bleeding is accomplished. It consists in the division or opening of a vein; the median cephalic vein is the one usually selected. (Fig. 139.) To perform venesection the surgeon requires a bistoury or lancet, several bandages, a small antiseptic dressing, and a basin to receive the blood. The patient's arm having been carefully sterilized, a few turns of a roller bandage should be placed around the middle of the arm, being applied tightly enough to obstruct the venous circulation and make the veins below prominent. The surgeon should next find the median cephalic vein, and, steadying it with the thumb and finger, should pass the point of the bistoury or lancet beneath it and cut quickly outward, making a free skin opening. The blood usually escapes freely, and the amount withdrawn is regulated by the condition of the pulse and the appearance of the patient. The patient should be in the sitting or semi-reclining position when venesection is performed,

as the surgeon can then better judge as to the constitutional effects of the loss of blood. When a sufficient quantity of blood has been removed, the thumb should be placed over the wounded vein and the bandage removed from the arm above. The wound should be washed with a bichloride solution, and a compress of antiseptic gauze applied over it and held in position by a bandage so applied as to envelop the arm from the fingers to the axilla. The dressing need not be disturbed for five or six days, at the end of which time the wound is usually found to be healed. Venesection is also sometimes practised upon the *external jugular vein* or upon the *internal saphenous vein*, in cases where the veins at the bend of the elbow cannot be easily found, as often happens in children.

TRANSFUSION AND INFUSION.

These two procedures are employed respectively to introduce blood or normal salt or saline solution into the body of a patient who suffers from *acute anæmia* resulting from profuse hemorrhage. Transfusion of blood is now rarely practised, and has been largely superseded by the intravenous injection or infusion of saline solution.

Direct Transfusion of Blood.—This is accomplished by making a direct communication between a vein of the person supplying the blood and one of the patient by means of a piece of rubber tubing, to the extremities of which are attached two canulæ. By introducing the canulæ respectively into a vein of the person supplying the blood and one of the patient, the current of blood is diverted from the former to the latter; the amount of blood introduced is regulated by the condition of the patient's pulse. Aveling's apparatus may also be employed for the direct transfusion of blood.

Auto-Transfusion of Blood.—Auto-transfusion is a procedure which is recommended in cases of excessive hemorrhage to support a moribund patient until other means of resuscitation can be adopted. It consists in the application of muslin or rubber bandages to the extremities for the purpose of forcing the blood towards the vascular and nervous centres.

Intravenous Injection or Infusion of Saline Solution.—Clinical experience has proved that the injection of saline solution into the veins is more efficacious in supplying volume to and restoring a rapidly failing circulation than that of human blood, and, as the former can be obtained with much more ease than blood, its use has largely superseded that of the latter. Normal saline solution (0.7 per cent.) is prepared as follows: sodii chloridi, ʒiss; sodii bicarb., gr. xv; aquæ dest., Oij; or, in cases of emergency, it may be prepared by adding a drachm of salt to a pint of boiled water. The solution should be used at a temperature of about 100° F. In injecting normal salt solution a vein of the patient, preferably at the elbow, should be exposed, and should have placed under it, about half an inch apart, two catgut ligatures; the distal ligature is then tied, and an opening is made into the vein between the ligatures. The canula is next inserted into the opening in the vein, and is secured in position by tying the proximal ligature. Before introducing the canula care should be taken that the canula, tube, and funnel are filled with saline solution, and

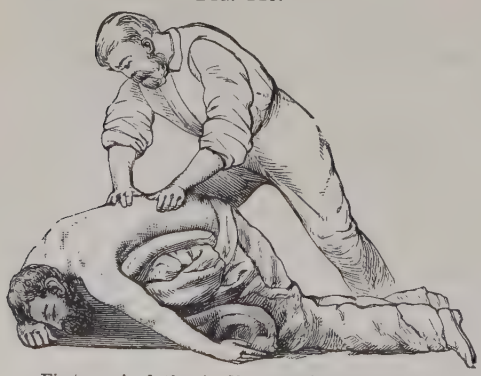
as the funnel is raised the saline solution passes into the vein, and the surgeon should see that the funnel is kept constantly filled with the solution; the quantity introduced should be regulated by the condition of the patient's pulse. When a sufficient quantity has been introduced, the canula should be removed and the catgut ligatures tied, and the wound should be closed with sutures.

Infusion.—Saline solution may also be introduced into the cellular tissue by means of a large hypodermic needle passed into the connective tissue and connected by a rubber tube with a reservoir containing the solution. The usual locations for the introduction of the solution are the external portions of the thighs and the anterior portion of the abdominal walls. As much as two or three pints of the solution have been introduced in this manner, with as satisfactory results as those obtained by intravenous injection.

ARTIFICIAL RESPIRATION.

Artificial respiration is resorted to in cases of threatened death from apnœa consequent upon profound anæsthetization, the inhalation of irrespirable gases, or drowning, or in cases where from any cause there is interference with the function of breathing. Before resorting to artificial respiration care should be taken that the mouth and air-passages are free from any substance which would obstruct the entrance of air into the lungs, such as mucus, foreign bodies, or liquids, and also that all tight clothing interfering with the free expansion of the chest-walls is removed. If there is a foreign body in the larynx or trachea, tracheotomy should be performed before artificial respiration is attempted. In practising artificial respiration the manipulations should be persevered in for some time, even if no apparent spontaneous respiratory movements are excited; for resuscitation has been accomplished in apparently hopeless cases by perseverance with the manipulations. As soon as natural respiratory movements are detected the surgeon should not cease artificial respiration, but should continue these manipulations in such a way as to coincide with the spontaneous inspiratory and expiratory movements until the breathing has assumed its regular character.

FIG. 140.



First manipulation in direct method of artificial respiration. (Howard.)

Direct Method of Artificial Respiration.—The manipulations in Howard's direct method of artificial respiration are as follows:

First.—"To expel water from the stomach and lungs, strip the patient to the waist, and if the jaws are clenched, separate them and keep them apart by placing between them a piece of cork or a small piece of wood. Place the patient face downward, the pit of the stomach being raised above the level of the mouth by a large roll of clothing placed

beneath it. (Fig. 140.) Throw your weight forcibly two or three times upon the patient's back, over the roll of clothing, so as to press all fluids in the stomach out of the mouth."

The first manipulations are applied only to cases of drowning.

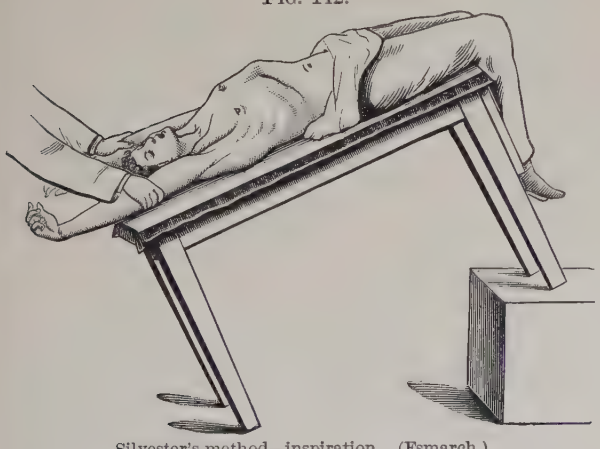
Second.—"To perform artificial respiration, turn the patient upon his back, placing the roll of clothing beneath it so as to make the breast-bone the highest point of the body. Kneel beside or astride the patient's hips. Grasp the front part of the chest on either side of the pit of the stomach, rest the fingers along the spaces between the short ribs. Press your elbows against your sides, and, steadily grasping and pressing forward and upward, throw your whole weight upon the chest, gradually increasing the pressure while you count one, two, three. (Fig. 141.) Then suddenly let go with a final push, which brings you back to your first position. Rest erect upon your knees while you count one, two; then make pressure again as before; repeat the entire motions, at first about four or five times a minute, gradually increasing them to about ten or twelve times. Use the same regularity as blowing bellows and as seen in the natural breathing which you are imitating."

Fig. 141.

Direct method of artificial respiration. (Howard.)

Silvester's Method of Artificial Respiration.—The patient should be placed upon his back upon a firm flat surface; a cushion should be placed under the shoulders, and the head should be dropped lower than the body by tilting the surface upon which it is laid. The mouth being cleared of mucus and foreign substances, the tongue should be drawn forward and secured, or held by an assistant. The operator, standing at the patient's head, grasps the arms at the elbows and carries them first outward and then upward until the hands are brought above the head; this manipulation represents inspiration. (Fig. 142.) They should be kept in this position for two seconds, after which they are brought slowly back to the sides of the thorax and pressed against it for two seconds; this manipulation represents expiration. (Fig. 143.) Simultaneous pressure on the abdomen by an

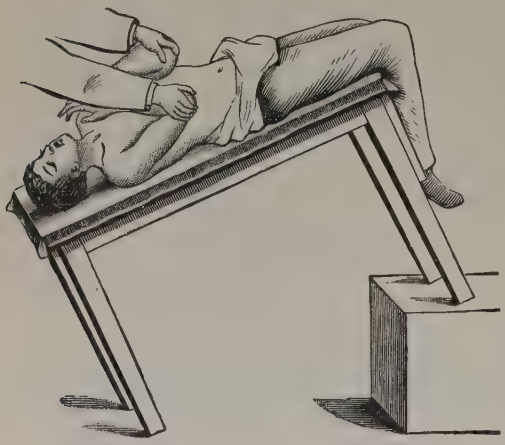
Fig. 142.



Silvester's method—inspiration. (Esmarch.)

assistant greatly increases the effect of this movement. These movements are repeated from twelve to fifteen times in a minute until the breathing is restored, or until it is evident that the case is a hopeless one.

Fig. 143.



Silvester's method—expiration. (Esmarch.)

Forced Respiration.—In this method of artificial respiration air is forced into the lungs either through the mouth and larynx or through a tracheotomy tube by means of a bellows. An intubation tube, to which a rubber tube is attached, may also be placed in the larynx, and to this is attached a bellows, or Fell's apparatus may be employed.

Forced respiration has proved of value in cases of narcotic poisoning and other accidents, in which death is produced by paralysis of the respiratory centres.

Laborde's Method of Artificial Respiration.—This method, which consists in systematic and rhythmic traction of the tongue, has proved to be a valuable means of restoring the respiratory reflex, and consequently the function of respiration. The procedure is accomplished as follows: The body of the tongue is seized between the thumb and the finger, or by tongue or dressing forceps, and traction is made upon it with alternate relaxation fifteen or twenty times in a minute, imitating the function of respiration, taking care to draw well on the tongue. As soon as a certain amount of resistance is felt it is a favorable sign, for it indicates that the respiratory function is being restored, which is manifested by noisy respiration. This form of artificial respiration bids fair to supersede all other forms, and has been employed with success in cases of drowning, toxic asphyxia, chloroform asphyxia, and asphyxia from strong electric currents. In any case where it is employed the traction should be persisted with for half an hour to an hour.

SUTURES.

Several varieties of materials are employed for sutures, such as silk, catgut, silver wire, silkworm-gut, kangaroo tendon, and horse-hair. Of these, catgut and kangaroo tendon are practically the only substances employed as sutures which are absorbed; the other sutures require removal, although some sutures, such as silk, silkworm-gut, and silver wire, when employed in deep wounds, if cut short, may become encysted and produce no trouble. It matters little what material be employed for sutures if it is rendered thoroughly aseptic before being brought in contact with the wound.

Sutures of Relaxation.—Sutures of relaxation, also called tension sutures, are those which are entered and brought out at some distance from

the edges of the wound, and are employed to prevent dangerous tension upon the sutures which approximate the edges of the skin. These sutures are employed in the form of the quilled, button, or plate suture.

Sutures of Coaptation.—These are superficial sutures applied closely together, and including only the skin. They are employed to secure accurate apposition of the cutaneous surfaces of wounds.

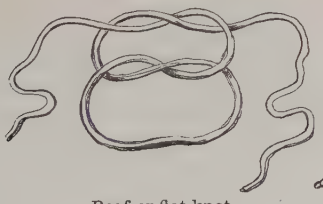
Sutures of Approximation.—These sutures are applied deeply into the tissues to secure approximation of the deep portions of a wound. They are often employed by means of the quilled, button, or plate suture.

Secondary Sutures.—These sutures are employed where primary sutures have failed to secure apposition of the edges of a wound, or in cases of secondary hemorrhage where the wound has been opened to turn out the blood-clot and secure a bleeding vessel; they are also employed where it is necessary to pack a wound with gauze, to control hemorrhage after the operation, or where hæmostatic forceps have been allowed to remain clamped upon bleeding tissues in the wound after an operation. The sutures may in such a case be introduced and loosely tied at this time, and when the packing or forceps is removed at the end of two or three days or after granulation has begun the sutures are tightened, so as to secure apposition of the edges of the wound.

Method of Securing Sutures.—Metallic sutures are usually secured by twisting the ends together, or by passing the ends through a perforated shot and clamping the shot with a shot-compressor. Sutures and ligatures of catgut, silk, silkworm-gut, or kangaroo tendon are secured by tying, and several different knots are employed in securing them.

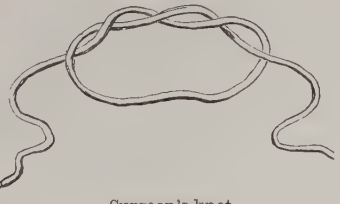
Reef or Flat Knot.—This is one of the best forms of knot to use in securing sutures or ligatures, and it is made by passing one end of the thread over and around the other end, and the knot thus formed is tightened. The ends of the thread are next carried towards each other, and the same end is again carried over and around the other; and when the loop is drawn tight we have formed the reef or flat knot. (Fig. 144.)

Fig. 144.



Reef or flat knot.

Fig. 145.



Surgeon's knot.

Surgeon's Knot.—This knot is formed by carrying one end of the thread twice around the other end, and, after tightening this loop, the same end is carried over and around the other end, as in the case of the final knot of the reef or flat knot. (Fig. 145.) The surgeon's knot and reef knot combined is a very excellent method of securing sutures or ligatures of catgut or silk, because in the ordinary method the first knot is apt to relax before the second knot is applied.

Interrupted Suture.—This variety of suture is the one usually employed in the apposition of wounds, and consists of a number of single stitches, each of which is entirely independent of those on either side. In applying this suture the surgeon holds the edge of the wound with the fingers or forceps, and thrusts the needle, previously threaded, through the skin from one-eighth to one-third of an inch from the edge of the wound. He next passes the needle from within outward through the tissues of the opposite flap at the same distance from the edge of the wound (Fig. 146); each stitch is secured as soon as it is applied, by tying if a silk, catgut, or silkworm-gut suture is used, or by twisting if a wire suture is employed. The suture may be used with a needle threaded on each end, in which case both needles are passed from within outward. In applying sutures care should be taken that they exert no tension on the edges of the wound, and that they are so introduced as to make the best possible apposition of the parts.

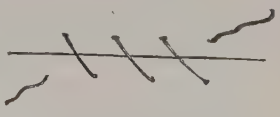
Fig. 146.

Interrupted suture.

Buried Sutures.—These are sutures which are introduced into deep wounds and cut short after being secured, and are allowed to remain in the wound, superficial sutures also being introduced. The former effect apposition of the muscles and the deep fascia; the superficial ones approximate the superficial fascia and the skin. The best materials to employ for deep or buried sutures are catgut, silk, or kangaroo tendon.

Continued Suture.—This suture is applied in the same manner as the interrupted suture, but the stitches are not cut apart and tied; it is secured by drawing it double through the last stitch, and using the free end to make a knot with the double portion attached to the needle. (Fig. 147.) This suture is often employed in securing apposition of the edges of wounds in tissues of loose structure.

Fig. 147.



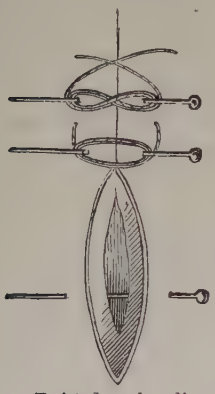
Continued suture.

Subcuticular Suture.—This variety of suture, which has been recommended by Halsted, is employed to avoid infection of the wound by the skin coccus, which may be introduced by the suture if passed from without inward. In applying this suture the needle is introduced on the under surface of the skin on one side, and is brought out just beneath the cut edge; it is then entered in the reverse direction below the epidermic surface opposite, and when tied it will lie wholly out of sight. For this suture fine silk or catgut should be used, which may become encysted, may be absorbed, or may be cast off.

Twisted or Harelip Suture.—This form of suture is employed where great accuracy and firmness of apposition of the surface of a wound are desired. It is applied by thrusting pins or needles deeply through both lips of the wound, the edges being brought in contact by figure-of-eight turns of silk or wire. (Fig. 148.) In using this suture the ends of the pins should be cut off with pin-cutters after the sutures are applied, or should be pro-

tected by pieces of cork or plaster to prevent them from injuring the skin. Harelip sutures are frequently employed in plastic operations about the face or other parts of the body where accurate apposition of the flaps is desired.

Fig. 148.



Twisted or harelip suture.

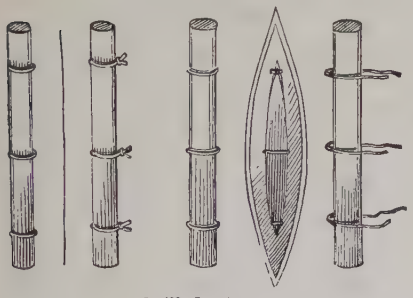
Quilt or Mattress Suture.—This form of suture is made with silk or catgut, and is employed in wounds where it is important to have very close approximation of the parts and to prevent bagging. (Fig. 149.)

Fig. 149.

Quilt or mattress suture.

Quilled Suture.—In applying this suture, a needle armed with a double thread of wire or silk is passed through the tissues as in applying the interrupted suture, but at a greater distance from the edges of the wound; the quill, or a piece of flexible catheter or roll of gauze, is inserted into the loops on one side of the wound, and on the opposite side the free ends of the sutures are carried around a similar object before being tightened. (Fig. 150.) This variety of suture makes deep and equable pressure along the whole line of the wound. In using this form of suture it is often found advisable to introduce a few superficial interrupted sutures along the line of the wound, to secure accurate approximation of the skin.

Fig. 150.



Quilled suture.

Fig. 151.

Button suture.

Fig. 152.

Shotted suture.

The use of deep or buried sutures to secure accurate apposition of the deep portions of the wound has largely supplanted the use of this variety of suture.

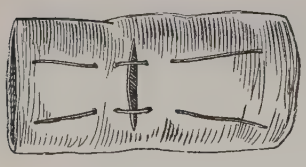
Button or Plate Suture.—In applying this suture, a thread armed with two needles is first passed through the eyes of a button or through perforations in a lead plate. The needles are next carried through the edges of the wound, and upon the opposite side are passed through the eyes

of another button or through the perforations of a lead plate. After the sutures have been passed in this way they are tightened and tied over the button or plate. (Fig. 151.) This variety of suture may be employed in deep wounds to accomplish the same purpose as the quilled suture, and, as it does not bring about very close apposition of the cutaneous margins of the wound, a few interrupted sutures may be employed in conjunction with it.

Shotted Suture.—The shotted suture receives its name from the method by which it is secured. After the suture has been introduced the needle is removed, and the ends are passed through a perforated shot and drawn upon to bring the edges of the wound in contact; the shot is then pressed down to the skin and clamped with a shot-compressor, and the suture is cut off flush with the surface of the shot. (Fig. 152.) This method of securing sutures is especially useful in closing wounds in mucous cavities, such as the vagina, rectum, and mouth, where a knot or twist of the wire or silkworm-gut might cause irritation. The presence of the shot also facilitates the removal of the suture, as the shot is not apt to be obscured by the swollen tissues, and is easily seized with forceps before the loop is divided.

Lembert's Suture.—This suture is generally used in wounds of the viscera covered by the peritoneum, with the object of bringing in contact the peritoneal surfaces. It is the form of suture usually employed in closing wounds of the intestine, bladder, or stomach. In applying this suture an ordinary sewing-needle should be employed, in preference to the bayonet-pointed needle, as less bleeding is apt to result from its puncture. The needle is first carried through the peritoneal and muscular coats of the intestine, and is then carried across the wound and passed through the same portion of the intestine a short distance from the edge of the wound on the opposite side; when the suture is tightened the peritoneal surfaces of the intestine are inverted and brought into contact with each other. (Fig. 153.) The interrupted or continued suture may be employed in making this form of suture.

Fig. 153.



Lembert's suture.

Removal of Sutures.—Catgut sutures usually undergo absorption in from five to fifteen days: the loop buried in the tissues is absorbed, and the knot may be removed with forceps or may come off with the dressings. Sutures of silk, silkworm-gut, or silver wire are removed by cutting one side of the loop and making traction upon the knot of the suture with forceps; in case of the silver wire suture, after dividing the loop and straightening out one end of it, the wire should be withdrawn in a curved direction. Sutures which do not cause any irritation should be allowed to remain in position until the wound is healed; the time usually required for their retention in the case of aseptic wounds is from eight to twelve days.

LIGATURES USED IN THE TREATMENT OF VASCULAR GROWTHS.

Various forms of ligatures are used for the strangulation of vascular growths. The material employed is usually strong silk, hemp thread, catgut, or silver wire.

Single Ligature.—This is applied by inserting a harelip pin through the skin near the edges of the growth, passing it under the growth, and bringing its point out through the skin opposite the point of entry; a strong silk or hemp ligature is then passed under the ends of the pin, surrounding the base of the tumor, is drawn tightly enough to strangulate the growth, and is secured by two knots. (Fig. 154.) If the growth is of considerable size, it is better before applying the ligature to introduce a second pin at right angles with the first one and then secure the ligature under the ends of the pins. In applying this ligature, the separation of the mass is hastened by cutting a groove in the skin with a knife at the point where the ligature is to be applied; the ligature when tied is buried in the groove thus made.

Fig. 154.

Single ligature applied with pin.

Fig. 155.

Double ligature.

The Double Ligature.—This ligature is applied by passing a needle, or a needle with a handle, armed with a double ligature, through the skin near the growth, and then passing it under the tumor and bringing it out through the skin at a point directly opposite the point of insertion; the ligature is then divided and the needle is removed. The growth is strangulated by tying firmly the corresponding ends of the ligature on each side of the tumor, each ligature including one-half of the growth. The double ligature may also be applied by passing a pin under the growth and then passing a needle armed with a double thread under the tumor at right angles to the pin. After removing the needle the ends of the ligature are tied and the tumor is strangulated in two sections. (Fig. 155.)

Quadruple Ligature.—In applying this ligature two needles, each carrying a double ligature, are passed under the growth at right angles to each other; the needles being removed, the surgeon ties two ends of the ligature together, and repeats the procedure until the growth has been strangulated in four sections.

Fig. 156.

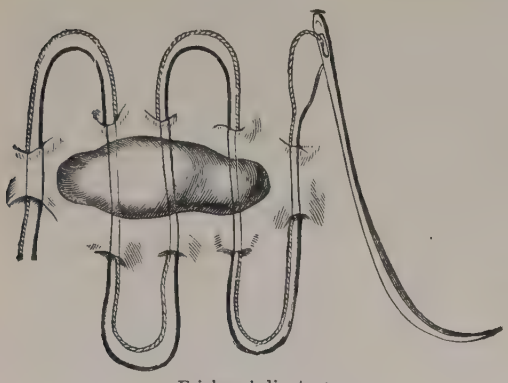
Subcutaneous ligature.

Subcutaneous Ligature.—The subcutaneous ligature is applied by introducing a needle armed with a ligature through the skin near the growth, and carrying it through the subcutaneous tissues around the growth for a short distance, then bringing it out through the skin. The needle is again introduced through the same puncture and again brought out through the skin at the same distance from the first point of exit, and is next introduced through this puncture and brought out at a more distant point. In this way the growth is completely encircled by a subcutaneous ligature, which is finally brought out at the point of entrance. The tumor is strangulated by firmly tying together the ends of the ligature.

(Fig. 156.) If a needle armed with a double ligature is first passed under the growth, the ligature is divided; by passing each end of the divided ligature subcutaneously around the growth it may be strangulated subcutaneously in two sections.

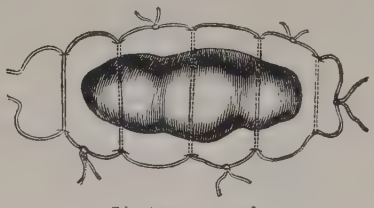
Erichsen's Ligature.—This ligature is employed to strangulate growths of irregular shape in a number of sections. Strong silk or hemp ligature, three yards in length, one-half of which is stained black, is threaded into a needle as a double ligature. The needle is then passed under the growth at various points, so as to leave a series of loops, about nine inches long, on each side of the tumor (Fig. 157), the black loops being cut on one side, the white on the other; the ends are then firmly tied, so as to strangulate the growth in a number of sections. (Fig. 158.)

Fig. 157.



Erichsen's ligature.

Fig. 158.



Ligatures secured.

Elastic Ligatures.—Ligatures made of india-rubber of various thicknesses are occasionally made use of in surgery. They may be used to strangulate growths, such as moles or nævi, or may be employed in the treatment of fistula. In applying an elastic ligature to a fistula the ligature, after being passed through the fistula by means of a probe, is carried out through the internal opening, and the ends of the ligature are tied firmly together; the greater the tension made before the ligature is tied, the more rapidly will it cut its way out.

CHAPTER X.

WOUNDS.

A WOUND is a solution of continuity or division of the soft tissues produced by cutting, tearing, or compressing force. Wounds are usually classified according to their causation or nature, as *incised*, when resulting from a sharp-edged instrument; *lacerated*, when the tissues are extensively torn or separated; *contused*, when resulting from a more diffused force tearing and bruising the tissues; *punctured*, when produced by some narrow instrument which causes a wound whose depth is greater than its external surface, such as a stab wound; *poisoned*, when some poisonous substance enters the wound and produces both local infection and constitutional disturbance; *gunshot*, when the injury results from fire-arms or the explosion of powder. The repair of wounds is considered upon page 69.

Contusions.—A contusion is a subcutaneous bruising or laceration of the soft parts, involving the connective tissue, the muscles, veins, arteries, lymphatics, and nerves, and in extreme cases the periosteum and bone may also suffer. When it involves only the superficial tissues it is known as a **bruise.** Contusions result from blows with blunt objects, and from violent compression of the parts, and the amount of injury inflicted depends upon the extent of the application of the force, and may vary from a mere bruise to a complete disorganization of the subcutaneous tissues. In slight contusions a few vessels are ruptured in the cellular tissue, giving rise to the discoloration or ecchymosis seen in ordinary bruises, which later develops the *black and blue* appearance. If the contusion of the parts is severe, a large quantity of blood may escape from the vessels, and if it becomes clotted it forms a coagulum in the tissues, which is known as a *thrombus.* If, however, the blood remains fluid and is circumscribed by the condensation of the surrounding tissues, it is known as a *hæmatoma.* Subcutaneous collections of effused blood, whether liquid or clotted, rarely suppurate, and usually undergo absorption. Accidental infection of the effusion may occur through sloughing of the skin covering it, or through injudicious attempts to remove the fluid by puncture. The effusion is sometimes surrounded by a layer of granulation-tissue, which is in time converted into fibrous tissue; the central portions of the effusion become decolorized, and, being surrounded by fibrous tissue, a serous cyst may be formed; in time the liquid portions may be absorbed, and a firm fibrous mass is left in the tissues.

Symptoms.—Pain of a dull character is usually present in contusions, and depends largely upon direct injury to the nerves or upon the amount of tension in the parts; swelling is always present to a greater or less extent, and

depends upon the amount of blood effused and the looseness of the tissues. Discoloration is another symptom which appears soon after the accident if the contusion is superficial, but may not appear for some days if the deep tissues are involved. In severe contusions shock is often a prominent symptom. If important vessels have been ruptured, the blood may escape in such quantities that the vitality of the tissues is impaired by tension, and gangrene may result, or the same result may follow from contusion and secondary occlusion of the blood-vessels. We have seen a severe contusion of the elbow involving the brachial vessels followed in a few days by gangrene, necessitating amputation of the arm. In severe contusions fever is usually present, its degree depending upon the amount of the extravasation and laceration of the tissues.

Treatment.—The skin covering a contused surface should be carefully examined, to see if any small wound or fissure exists through which the subjacent tissues may become infected. If such is found, it as well as the skin should be carefully washed with soap and water and irrigated with a 1 to 2000 bichloride solution, and the small wounds should be covered with strips of gauze and iodoform collodion. The application which we have found to give the most comfort to the patient and to hasten the absorption of the effused blood is the following: Ammonii chloridi, ʒii; tr. opii, fʒss; alcoholis, fʒss; aquæ, fʒvi. Lint is saturated with this lotion and laid on the contused part, which is covered with waxed paper or oiled silk; a layer of cotton and a bandage being next applied over the dressing with moderate firmness. *Rest* is an important part of the treatment not only of contused wounds but of all varieties of wounds. It may be secured by putting the patient to bed, by the use of splints and bandages, or of fixed dressings, such as the plaster of Paris or silicate of sodium dressing, or by the use of strapping. In contusions of the back we have found that the most satisfactory treatment consists in strapping the parts firmly with strips of rubber or adhesive plaster, two and a half inches in width, applied so as to extend some distance in all directions beyond the contused tissues. In the later stages of contusions with effusion of blood the absorption of the latter may be hastened by massage.

Strangulation of Parts.—When a part has its circulation interfered with by the application of a constricting band, it rapidly becomes swollen and discolored, and soon passes into a condition of gangrene. Strangulation of parts often occurs from the application of a too tight bandage, or from the presence of a tight ring upon a part which has been injured and becomes swollen, and unless the constriction be promptly relieved the parts soon become gangrenous.

Treatment.—In the treatment of a part which has been strangulated by a tight band the first indication is to remove the constricting band; this can usually be done without difficulty, but in the case of metal rings their removal is often more troublesome. In removing rings from the fingers the part in advance of the ring should be firmly wrapped with a piece of tape, the end of which is carried under the ring, and as it is unwound the ring may be slipped off; if, however, the ring cannot be removed in this way, it may be necessary to divide it with a file or forceps. The swollen and

œdematous condition of the parts caused by strangulation may be in a measure relieved by free incisions, which permit of the escape of the effused fluids and diminish the risk of gangrene. After the incisions have been made the parts should be irrigated with an antiseptic solution, and an antiseptic dressing applied.

Incised Wounds.—An incised wound is one which is produced by some sharp-edged instrument, such as a knife, an axe, or a piece of glass, china, or metal, which divides the tissues cleanly, producing no bruising or tearing. In incised wounds there is usually some retraction of the edges of the wound and subjacent tissues, the amount of retraction depending largely upon the extent and direction of the division of the subjacent fascia and muscular tissue and the natural elasticity of the structures. The surgeon in making incised wounds in operations bears this fact in mind and avoids the transverse division of the muscles, recognizing the greater difficulty which will be experienced in bringing about coaptation of the edges of such a wound and the strain which will naturally follow upon the cicatrix. The *pain* in incised wounds is usually of a sharp, burning character, and varies with the nature of the instrument by which it is inflicted; a sharp instrument produces less pain than a dull one, and the pain varies also with the part upon which the wound is inflicted, wounds of parts freely supplied with nerve-filaments being more painful than those of parts in which they are less abundant. *Hemorrhage* is usually free in incised wounds, but varies with the number and size of the vessels divided. In incised wounds of the scalp free hemorrhage occurs even if no large vessels are divided, for the reason that the density of the structure of the scalp prevents retraction and contraction of the vessels. In incised wounds of the hands and face the bleeding is also very profuse, even when no large vessels are injured, because of the great vascularity of the parts.

Treatment.—Incised wounds, for convenience of treatment, should be divided into two classes: those which are inflicted by the surgeon, which should be aseptic wounds, and those which result from accident and may or may not be infected before they come under the surgeon's care.

Incised Wounds produced by the Surgeon.—In these wounds, if rigid aseptic precautions have been observed, we have all the conditions present for rapid repair, as the division of important nerves, tendons, arteries, and veins has been as far as possible avoided, and the incisions have been so planned as to avoid transverse section of the muscles, thus preventing gaping of the wound. Before examining or treating any form of open wound the surgeon should be careful that his hands have been sterilized, and that only sterile instruments, sponges, pads, ligatures, and sutures are brought into contact with it.

Treatment.—In the treatment of such wounds, after controlling the bleeding by pressure, or by ligature if necessary, and providing for drainage by the introduction of a drainage-tube, if the wound is an extensive or a deep one, the deep parts of the wound may be brought together, if it be thought advisable, by the use of buried sutures of catgut or silk; the edges of the superficial wound are next approximated by continuous or interrupted

sutures of silk, catgut, or silkworm-gut, and a dressing of sterilized or antiseptic gauze and cotton is then applied.

Accidental Incised Wounds.—In the treatment of these wounds a careful exploration of the wound is necessary to ascertain its extent and whether any important structures have been divided. Too much attention cannot be paid to the examination of this variety of incised wounds, for we have seen patients in whom such wounds of the hands and of the forearm had been closed without such examination, and after healing it was found that the hands were useless by reason of the fact that divided nerves or tendons had not been approximated by sutures before the wounds were closed.

The fact that the wound may have been infected should be considered by the surgeon, and should lead him to use some form of irrigation before closing the wound.

Treatment.—The surgeon should first separate the edges of the wound and irrigate it with a 1 to 2000 bichloride solution or sterilized water, and if there is any bleeding the vessels should be found and tied. If the wound is so deep that its lowest portion cannot be well explored, it may be necessary to enlarge it by increasing the length of the original wound superficially, or by a transverse incision. When the surgeon has satisfied himself that no important structures have been divided, the wound may be closed, as will be described later. If upon exploration of the wound he finds that an important nerve or tendon has been divided, that muscles have been divided transversely, or that an important fascia has been severed, these structures should be brought together by sutures before the wound is closed. Suturing of the deep fascia will often prevent hernia of the muscles after the wound has healed.

When the surgeon has satisfied himself that the wound is in condition to close, if the wound be a deep one, he should introduce a rubber drainage-tube or a few strands of catgut, to secure free drainage. Sutures should be introduced to approximate the edges of the wound, and it should next be covered with a number of layers of sterilized gauze or bichloride gauze and a few layers of sterilized or bichloride cotton, and the dressings held in position by a gauze bandage.

If a drainage-tube has been employed, the dressing should be changed in three or four days, the drainage-tube removed, and the wound should be dressed as previously described. If the wound runs an aseptic course it usually requires no dressing for another week, at which time the dressings should be taken off and the sutures should be removed, the wound usually being found perfectly healed. It is well, however, to keep the cicatrix covered for a little longer time with a pad of gauze or cotton to protect it.

In approximating deep wounds involving the muscles, the surgeon should be careful to put the parts in such a position as to take advantage of muscular relaxation.

Superficial incised wounds involving only the skin or the skin and cellular tissue, if of limited extent, may be irrigated, the edges being brought together by a few sutures, no drainage being required; the wound may then be covered by a few strips of gauze, which is next painted over with

iodoform collodion, several layers of strips and collodion being applied so that the whole wound is covered by an antiseptic scab of gauze and iodoform collodion.

Lacerated Wounds.—Lacerated wounds are such as have resulted from blunt instruments which have torn the skin and subcutaneous tissues. These wounds result from machinery accidents or from heavy bodies passing over the parts, as the wheels of wagons or cars, and present irregular and jagged edges with extensive laceration of the subcutaneous tissues, and are also apt to contain a considerable quantity of foreign matter which has been ground into the tissues. The most serious lacerated wounds occur as the result of machinery accidents, the extremities or other portions of the body being caught by belting or drawn between cog-wheels or rollers, or the hands being caught in the picking machines employed in cotton or woollen mills. As the result of such injuries the parts may be completely disorganized, or *avulsion* of a greater or lesser portion of the limb may occur. In such wounds extensive removal of the skin may occur without serious injury to the deeper parts. Extensive lacerations of the body are also seen as the results of railway accidents and from the body being caught in the fall of timbers, stones, or earth, or in blasting accidents. The pain in lacerated wounds is usually of a dull character, and the bleeding is not apt to be profuse unless large vessels have been torn, it being, as a rule, controlled by the twisting and bruising of the vessels. Secondary hemorrhage is, however, likely to occur in this variety of wounds, particularly if infection and sloughing take place. We have seen the femoral artery exposed in a case of avulsion of the thigh from railroad injury, and although it pulsated to within an inch or two of its divided extremity not a drop of blood escaped from it. In this variety of wounds the vitality of the tissues is much impaired, so that sloughing to a greater or lesser extent is apt to occur. Shock is often well developed in severe lacerated wounds. Lacerated wounds usually heal by granulation, except when they occur in a very vascular part, such as the face, in which case union by adhesion may result.

Treatment.—In the treatment of lacerated wounds the first indication is to arrest hemorrhage, if it is present to any considerable extent; the wounds should next be irrigated with a 1 to 2000 bichloride solution or normal salt solution, to remove blood-clots and any foreign bodies which may be present, and the skin surrounding the wounds should be rubbed over with spirit of turpentine, and next with soap and water, and finally irrigated with bichloride solution. Many lacerated wounds, especially those which result from machinery and railroad accidents, have grease, dirt, and cinders ground into the tissues, and it is often a difficult matter to remove these entirely. Turpentine may be employed to dissolve the grease, and soap and water should be freely used, followed by a 1 to 2000 bichloride solution. Much of the foreign matter may be removed by forceps and a curette, and it is sometimes necessary to trim away with scissors tissue which has dirt so thoroughly incorporated with it that it cannot be cleansed. Divided tendons, nerves, or muscles should be brought together by sutures. When the wound has been cleansed as thoroughly as possible, the question of ap-

proximating the edges has to be considered. As a rule, the introduction of sutures in lacerated wounds is to be avoided, unless a few be used to hold the edges of flaps loosely in contact. If attempts be made to approximate closely the edges of lacerated wounds by sutures, great tension is apt to result from swelling of the tissues, which may cause gangrene of the parts, which are often partially devitalized by the traumatism. Partially detached portions of the tissue or skin may be placed in their normal positions and secured by a few loosely applied sutures, and if deep cavities exist, drainage-tubes should be introduced. The wound should then be covered with a piece of sterilized protective or rubber tissue large enough to cover the raw surface of the wound, and over this should be placed a number of layers of sterilized or bichloride gauze and a few layers of bichloride cotton, the dressings being held in position by a gauze bandage. Even if the wound has been rendered aseptic and remains so, there is usually free oozing of serum, which soaks the dressings and necessitates their removal in a few days, at which time the wound should be redressed in the same manner.

Avulsion of a limb, or extensive lacerations of the extremities when the vitality of the parts is destroyed, demand primary amputation. Where the part has been completely stripped of skin, or a limb has been completely girdled, immediate skin-grafting may occasionally be employed with success, but in the latter case amputation as a primary procedure is generally indicated. In the case of *avulsion of the scalp*, if the detached scalp is not extensively lacerated, the wound should be sterilized, and the scalp should be replaced and held in place by a few sutures and a gauze compress and bandage, and in some cases adhesion may occur. If the scalp does not retain its vitality, skin-grafting may subsequently be employed.

Another method of treatment of severe lacerated wounds is by *continuous antiseptic irrigation*, which is especially applicable to lacerated wounds of the extremities. In applying this method of treatment the wound and surrounding skin should first be cleansed and foreign bodies removed; the limb should next be arranged upon pillows covered by rubber sheets so that the fluid passing over the wound can escape into a vessel and not wet the patient's bed. The skin of the limb for some distance around the wound should be rubbed with cosmoline, to prevent its becoming sodden from the continuous presence of moisture. The fluid used for irrigation is a 1 to 4000 to 1 to 8000 bichloride solution, warm or about the temperature of the body, which is allowed to run drop by drop over the part from an irrigating-can with a stopcock to regulate the flow of fluid, or from an improvised irrigator made from a jar and a few pieces of lamp-wick. The irrigating reservoir should be placed only a few inches above the wound. This form of irrigation may be kept up for days, and under its use lacerated wounds often become clean and covered with healthy granulations. When the wound is in this condition, dry sterilized dressings may be substituted, or it may be dressed with boric ointment. In lacerated wounds in which suppuration or sloughing has occurred after the ordinary antiseptic dry dressings have been applied, it is often found of advantage to apply continuous antiseptic irrigation.

In lacerated wounds where a large granulating surface exists, much time

in healing may be saved and often excessive contraction of neighboring parts avoided by making use of some of the various methods of skin-grafting. (See pages 245, 246.)

Contused Wounds.—A contused wound is one in which the edges of the wound and the surrounding tissues have been bruised or crushed, the subcutaneous tissues often being severely damaged far beyond the area of the skin wound. Contused and lacerated wounds have many features in common and often result from the same causes. The best examples of contused wounds are those resulting from heavy bodies passing over parts, where the skin wound is insignificant, but the subcutaneous tissues are often completely pulpified and the bones comminuted. Contused wounds if extensive and severe are usually accompanied by marked shock. External bleeding, as a rule, is not excessive, although there may be extensive subcutaneous hemorrhage. Sloughing and gangrene may occur, complications which in wounds of the extremities may demand amputation.

Treatment.—In a contused wound where there is great distention of the parts from effused blood and serum, and the wound is small, it is often advisable to enlarge it, and if the collection is below the deep fascia, to divide this also to the full extent of the external wound, to give exit to the effused fluids. Incisions may also be made at other parts to accomplish the same object. This may so diminish the tension of the parts that gangrene will be averted.

Before making such incisions the parts should be thoroughly sterilized. After the incision has been made, copious moist antiseptic dressings should be applied, either bichloride or acetate of aluminum gauze being employed, these dressings being removed as they become soaked with discharges from the wound. Continuous antiseptic irrigation may also be employed in the treatment of contused wounds, as described in the treatment of lacerated wounds.

The conditions presented by contused wounds are so similar to those in lacerated wounds that the same methods of treatment may be adopted, and the same caution should be observed not to attempt to approximate the edges of the wounds by means of sutures.

Brush-Burn.—This is a form of superficial contused wound which is produced by friction applied to the surface of the body. The appearance of a well-marked brush-burn is very similar to that of a burn or scald after the cuticle has separated. This form of injury often occurs from a rope being rapidly drawn through the closed hands, or from parts of the body coming in contact with rapidly moving belting or machinery, or from the body being dragged violently over a rough surface. This injury may be superficial and involve only the external layer of the skin, or may involve the whole thickness of the skin.

Treatment.—If the brush-burn is superficial, the surface should be irrigated with a 1 to 2000 bichloride solution and dusted with powdered boric acid, and a sterilized gauze dressing should be applied. If, however, the injury involves the true skin, sloughs are apt to form, and here the dressings should consist of gauze which has been moistened in carbolic or boric or acetate of aluminum solution, which should be applied until

the sloughs have separated, when an ointment of boric acid may be substituted.

Punctured Wounds.—These wounds are produced by thrusts from pointed instruments, such as knives, swords, bayonets, nails, splinters of wood or metal, wire, sticks, or needles, and their depth is much greater than their superficial area. The character of a punctured wound depends upon the object by which it is produced. The wound resulting from the puncture of a knife or of a narrow strip of metal or glass will resemble an incised wound, while that resulting from a rough stick or splinter or from the ferrule of a cane will be a contused or a lacerated wound. Punctured wounds produced by clean and smooth instruments, unless important vessels or nerves have been injured or important cavities penetrated, are accompanied by no more risk than incised wounds, and heal as promptly. If, however, the wound is produced by a rough or an infected instrument, or if vessels have been divided, suppuration is more likely to occur than in open wounds, and is liable to spread widely through the tissues. If important vessels are divided, hemorrhage occurs, and the punctured wound of an artery may give rise to a *traumatic aneurism*, or the simultaneous puncture of a vein and an artery in close proximity may cause an *arterio-venous aneurism* or an *aneurismal varix*. The instrument inflicting the punctured wound may break, and a portion of it remain in the wound and cause subsequent irritation. A common form of punctured wound is caused by a needle penetrating the body and a portion breaking off and remaining in the tissues. (Fig. 159.)

Fig. 159.

Skiagraph of a needle in the hand.

Treatment.—Punctured wounds produced by clean, smooth instruments usually heal promptly, and their treatment consists in irrigating the parts to secure asepsis, and applying an aseptic or an antiseptic dressing.

In a punctured wound in which free bleeding occurs, or in which the region of the wound is stuffed with blood, it is necessary to enlarge the wound and turn out the clotted or fluid blood and find the injured vessel, complete its division if only partly divided, and secure its ends by means of ligatures.

In punctured wounds made by rough or infected instruments, the wounds should be enlarged by free incisions and irrigated with a 1 to 2000 bichloride solution, a drainage-tube being inserted if necessary, and the wounds should be dressed with sterilized or bichloride gauze.

In a punctured wound in which the penetrating body has broken and a portion of it remains in the tissues, the wound should be enlarged and the foreign body sought for and removed. In searching for foreign bodies in punctured wounds, such as needles, or splinters of wood or of metal, the

Esmarch bandage is most useful, as the surgeon in enlarging the wound is not embarrassed by hemorrhage, and is able often to see and follow the track of the body and recognize the different tissues. The Röntgen or X rays have recently been employed with success in locating foreign bodies, such as pieces of metal or glass, in punctured wounds. By their use a skiagraph may be obtained by which the foreign bodies may be located. (Fig. 160.) As a matter of course, rigid asepsis should be observed in enlarging these wounds and in their subsequent dressings.

Fig. 160.

Skiagraph of a piece of a needle in the foot.

When the vulnerating body is barbed, as in the case of an ordinary fish-hook, and remains in the tissues, its withdrawal is often difficult, and it has to be cut down upon and removed, or, if embedded in the fingers, as is often the case, it can be pressed through until its barbed end projects upon the other side, when, this being cut off with cutting pliers, the shaft can be withdrawn.

Arrow Wounds.—This variety of wounds is not seen in civil practice, but is common in conflicts with savage tribes. They give rise to serious injuries, and are often fatal if they involve the thoracic or the abdominal cavity. The head of the arrow attached to the shaft may become fixed in a bone, or it may become detached and remain in the tissues.

Treatment.—Attempts should be made to remove the head of the arrow by traction, or by enlarging the wound if necessary and grasping it with forceps, or, when it has penetrated a part and is near the surface upon the opposite side, it may be pressed through, when, the head being removed, the shaft is withdrawn. After the removal of the arrow the wound should be enlarged and irrigated, and a bichloride or sterilized gauze dressing applied.

Sword Wounds.—Sword wounds may be of the nature of incised wounds, punctured wounds, or contused and lacerated wounds. They should be irrigated with an antiseptic solution, and if external and clean-cut they should be closed with sutures. If they penetrate important cavities they should be treated on the same principle as other punctured wounds of cavities.

Bayonet Wounds.—These wounds vary with the shape of the bayonet with which they are inflicted—either the triangular-shaped or the sword-shaped bayonet. Bayonet wounds are said to be especially liable to be infected and cause deep-seated suppuration. The wound produced by the sword bayonet is of the nature of an incised wound, and heals more promptly than that produced by the triangular-shaped bayonet. The wounds should be irrigated with a 1 to 2000 bichloride solution, and a bichloride gauze dressing applied.

POISONED WOUNDS.

Dissection Wounds.—Wounds received in the dissection of dead bodies or in making post-mortem examinations often present a special virulence. Poisoned wounds of this variety are usually received in the post-mortem examination of bodies recently dead from infectious diseases, the poison entering through a wound or an abrasion, but may also occur through absorption by the sweat-glands or sebaceous glands. Bodies in which death has occurred from septic peritonitis, erysipelas, pyæmia, and septicæmia are most likely to give rise to serious infection of post-mortem wounds. The infective micro-organisms, however, retain their virulence for only a short time after death, and are replaced by the bacteria of putrefaction. Persons who handle dead animals may be infected through wounds or abrasions, and may develop wounds of the same character.

Infection may develop in wounds received by the surgeon in operating upon infected cases, giving rise to a similar specific infection, or a mixed infection may result.

Individuals vary in their susceptibility to the infection of wounds received in post-mortem examinations and in operating upon infected subjects. If the individual be in ill health the constitutional resistance is diminished, and a wound accompanied by serious symptoms is more apt to develop.

Symptoms.—The symptoms following a dissection wound vary with the character and the amount of the poison introduced. Occasionally the symptoms following such a wound are those of acute septic intoxication; the wound becomes painful, red, and swollen, and sloughing of the tissues in the neighborhood of the wound may occur; the patient exhibits the symptoms of collapse, the pulse becoming rapid and feeble, and he may become delirious and die in a few days. A cellulitis may develop which rapidly extends up the arm, the temperature being 103° F. (38.5° C.) or 104° F. (40° C.), the pulse rapid and feeble, with profuse sweating; suppuration or gangrene may occur, and the patient may die of septicæmia, pyæmia, or exhaustion, or may recover after a protracted illness. On the other hand, the wound may become red and painful, a papule or pustule may develop, and the lymphatic vessels, becoming inflamed, may be seen as red lines running up the arm. The axillary glands become enlarged and painful, and the patient complains of a chilly feeling, followed by marked fever; an abscess develops, and after this is opened the local and constitutional symptoms rapidly disappear.

Owing to the fact that infection may occur from an unsuspected abrasion of the skin, or from absorption of the poison by the sweat-glands or sebaceous glands, it is a wise precaution before making post-mortem examinations to smear the hands thoroughly with cosmoline or lard.

Treatment.—The prompt treatment of a wound received in dissecting or in operating may prevent serious consequences. If one receives a wound in making a post-mortem examination upon a subject who has died of an infectious disease, or in operating upon an infected subject, the wound should be shut off from the general circulation by a ligature, firmly tied above the part, thoroughly washed, as well as the surrounding skin, with a 1 to 1000 bichloride solution, then sucked, and its surface wiped over

with a thirty-grain solution of chloride of zinc. The ligature should then be removed, and the wound dressed with a moist dressing of bichloride or acetate of aluminum gauze and cotton.

When infection of the wound has occurred, as evidenced by severe pain, the development of a pustule, and inflammation of the lymphatic vessels and glands, the treatment should consist in first thoroughly washing the parts with soap and water and bichloride solution; the pustule being opened, and the skin freely trimmed away, so as to obtain a full exposure of the wound, this should be washed with a 1 to 2000 bichloride solution, and swabbed with a thirty-grain solution of chloride of zinc. The wound should then be dressed with moist acetate of aluminum or sublimated gauze, and the patient should be given quinine in full doses, and stimulants if the appetite fails. Under this treatment, even when the lymphatic vessels and glands were involved, we have usually seen the local trouble as well as the constitutional disturbance rapidly disappear. In cases which exhibit symptoms of acute septic intoxication from the start, unfortunately, treatment seems to have very little effect: the wound and swollen tissues should be incised to relieve tension, irrigated with a 1 to 2000 bichloride solution, and dressed with a moist antiseptic dressing. The patient should be given quinine and tincture of chloride of iron in full doses, as well as strychnine and stimulants, and should also be given a concentrated and nutritious diet. If immediate death is averted, sloughing and profuse suppuration, with septicæmia or pyæmia, may cause a fatal termination at a later period; if the patient does not succumb, it may be a long time before he regains his health. Change of air and scene is very important in establishing convalescence, and should be recommended as soon as the patient can be moved.

Anatomical Tubercle.—This name is applied to warty or papular growths which occur upon the thin skin of the back of the hand, over the knuckles and the metacarpal bones, of those who constantly handle the dead bodies of human beings or animals. (Fig. 161.) The growths consist of enlargements of the cutaneous papillæ, which are covered with a dense layer of epidermis, presenting somewhat the appearance of ordinary warts. They are tender upon pressure, and if irritated serum exudes, which may dry and form scabs upon their surface. Recent investigations have shown that many of these growths are due to the local inoculation of tubercle bacilli. Anatomical tubercle is not a common affection in this country, but is quite common in Europe.

Fig. 161.

Anatomical tubercle. (Bryant.)

Treatment.—If the hands are protected from the causes which favored their development, the growths will often disappear; if, however, the growths fail to disappear after the cause of irritation has been removed, nitric or acetic acid should be applied to them, and will accomplish their removal. If the surface involved is extensive, they may be removed by the use of a curette.

Stings of Insects.—These wounds, produced by bees, wasps, spiders, or bugs, although often exceedingly painful for a short time, are usually followed by no serious consequences. In tropical climates, however, it is said, the stings of spiders, centipedes, tarantulas, and scorpions may result in death; and death has been recorded from the stings of bees when a large number of stings were inflicted upon the face and scalp. The fatal cases of insect-stings have generally been preceded by inflammation and gangrene of the parts injured, and it is possible in these cases that the stings were simply the wounds of entrance for microbic infection. We have seen a few cases of serious phlegmonous cellulitis, especially upon the face and hands, following the bites or stings of insects, and have also seen very serious œdema of the tongue resulting from the sting of a bee.

Treatment.—As the poison in insect stings or bites is principally an acid, it is often found that the pain is relieved by the application of an alkali, such as dilute aqua ammoniæ or solution of carbonate of sodium. A preparation made from carbolic acid and camphor, known as *camphophénique*, is a very satisfactory application to the stings or bites of insects.

Snake-Bites.—The venomous serpents in the United States are the rattlesnake, moccasin, and copperhead. The poisonous fluid in these serpents is secreted by a pair of glands situated on each side of the upper jaw, and is conducted by ducts to the grooved or hollow fangs in the upper jaw. According to Weir Mitchell, the poison renders the blood incoagulable, disintegrates the red corpuscles, and causes wide-spread blood-extravasation by acting upon the walls of the capillaries, hemorrhage into the medulla, profound depression of the respiratory nerve-centres, and cardiac paralysis.

Symptoms.—The symptoms following the bite of a poisonous snake depend upon the amount of poison introduced and the rapidity of its absorption. There are often pain and swelling in the region of the bite, ecchymosis develops rapidly, and cardiac depression is soon manifested by a feeble and fluttering pulse, with marked respiratory depression, pain, vomiting, and labored breathing. Death usually occurs in from twenty-four to forty-eight hours. In some cases death results rapidly from direct action of the poison upon the cardiac centres.

Treatment.—The first indication in the treatment of a bite from a poisonous serpent is to prevent, as far as possible, the entrance of the poison into the circulation. If the bite be upon the fingers, hand, foot, or limbs, a tight band should be twisted around the part above the seat of injury, and suction should be made upon the wound with the mouth to encourage bleeding and removal of the poison. When it is not possible to shut off the circulation, the wound should be promptly excised. The constricting band may be removed at intervals (*the intermittent ligature*) if the vitality of the parts be threatened, so that only a small amount of the poison enters the system at one time. The use of permanganate of potassium injected into the wound hypodermically is highly recommended, as well as the intravenous injection of ammonia. The constitutional treatment of snake-bites consists in the use of alcohol or whiskey in full doses; and cardiac stimulants, the best of which is strychnine, should also be administered if they are available.

Bites of Animals.—Bites of animals, unless they at the time are suffering from rabies, usually inflict only lacerated wounds. Bites of animals suffering from *rabies* introduce a specific poison into the system (see page 67). They, however, inflict lacerated wounds which may become infected by micro-organisms upon the teeth or in the saliva and give rise to serious symptoms. We have seen very serious wounds inflicted by rat-bites, the wounds becoming inflamed, œdematous, and gangrenous, and being accompanied by more or less constitutional disturbance. Bites of horses may cause serious wounds, on account of the crushing of the tissues, followed by extensive sloughing of the soft parts and necrosis of the bones. Bites of human beings often result in wounds which run the same course. We have seen several cases of necrosis of the metacarpal bones from injuries received upon the knuckles from human teeth.

Treatment.—As the complications following bites of animals are probably due to microbic infection, it is most important in the treatment of the wounds that they should be first completely cleansed by washing with an antiseptic solution, and then dressed with an antiseptic or aseptic dressing.

GUNSHOT WOUNDS.

Gunshot wounds may be described as those which result from missiles whose force is derived from the explosion of gunpowder. In military practice such wounds are produced by rifle-balls of various kinds, solid shot, canister, shot and shells, and by splinters of wood or metal or rock set in motion by some of this variety of projectiles.

The gunshot wounds which the surgeon meets with in civil practice usually result from small shot or pistol-balls, although he occasionally sees wounds produced by fragments of metal and splinters of wood from the bursting of small-arms, or from fragments of rock in blasting accidents, which correspond very closely to shell wounds in military practice.

Very serious or fatal gunshot injury may be inflicted by the discharge of powder or the wadding of a gun fired at close range, producing lacerated and contused wounds in conjunction with burns.

General Characteristics of Gunshot Wounds.—Gunshot wounds are contused and lacerated wounds, and present much variation in character, according to the nature of the projectile with which they are inflicted and its momentum. The injury of the tissues with which the projectile comes in contact often diminishes their vitality to such an extent that more or less sloughing occurs; their repair is also further interfered with in many cases by foreign bodies which are carried into the wound, such as portions of the clothing, gun-wadding, splinters of wood, etc.

The majority of gunshot wounds have two apertures,—one made by the entrance of the ball, the other by its exit; the wound of entrance is, with some exceptions, smaller than the wound of exit; the size of the latter is increased by the tissues driven out with the ball, by the distention of the tissues, and probably also by the diminished velocity of the ball. When one wound only exists it may usually be inferred that the ball remains in the body. The wound of exit does not always occupy a position in the

same line as the wound of entrance, for the ball may be deflected from its course by coming in contact with strong fasciæ, tendons, cartilage, or bone; in a gunshot wound of the anterior portion of the chest, the ball may strike a rib, and following this backward may have its wound of exit near the spine, or may be found embedded in the muscle upon the side of the spine. One ball may also produce several wounds of entrance and exit: a ball striking the flexed leg may penetrate this as well as the thigh, producing four wounds, or may penetrate one of the extremities as well as the body. The wound may be infected by the ball or shot, or by portions of the clothing or skin carried into the wound by the projectile. Where large vessels or important organs are not injured, the favorable or unfavorable course of the wound depends largely upon the absence or presence of the primary infection of the wound.

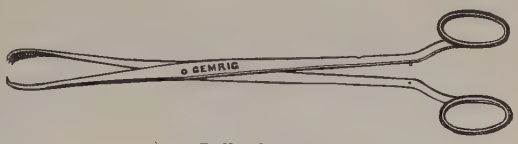
A gunshot wound is practically a subcutaneous injury, and if the track of the wound is kept free from infection from without, although the tissues are contused and lacerated, healing often takes place without the occurrence of suppuration. Experience has shown that infection of gunshot wounds from the projectile itself is not common, and this has led surgeons to be less zealous in exploring and enlarging these wounds in attempts to remove the missiles. There is a popular belief that the dangers of a gunshot wound are much diminished by the removal of the ball, which will often cause the patient and his friends to insist upon the surgeon's making some attempt to remove the ball, but this should not lead the surgeon to alter his judgment if he considers the case one in which attempts to remove the ball should not be made. When a ball can be located without difficulty it is well to remove it, but when the search for and removal of the ball necessitate an extensive dissection of the tissues it is much better to let it remain. The position of a ball may be located by palpation of the tissues, by the introduction of the finger into the wound, or more frequently by the use of a probe. The white porcelain-tipped probe of Nélaton, which shows a lead mark if it comes in contact with the ball, will often be found useful in locating the ball. The *Röntgen* or X rays and the *fluoroscope* have been employed with success to locate the position of bullets embedded in the tissues. By exposing the part in which the ball is supposed to be lodged to these rays for a few minutes a skiagraph may be obtained by which the position of the bullet may be located. (Fig. 162.) All probing should be done with extreme gentleness; this is especially the case when the probe is passed into soft tissues, where the application of force might cause the probe to make a track for itself. Various

FIG. 162.

Skiagraph of ball embedded in metacarpal bone. (Leonard.)

forms of electrical instruments have been devised to determine the presence and locate the position of balls in gunshot wounds, and of these the most satisfactory is the telephonic probe of Girdner. When the bullet has been located it may be removed through the wound of entrance, or by making a counter-opening where it occupies a position near the skin and can be reached without much division of the tissues. The form of bullet forceps most convenient for use is that shown in Fig. 163.

Fig. 163.



Bullet forceps.

Symptoms.—The symptoms following a gunshot wound will vary with the location of the wound, the nature of the missile, and the extent of injury to the various tissues.

Shock is a prominent symptom in gunshot wounds involving the great cavities of the body or those accompanied by extensive laceration of the soft parts with comminution of the bones.

Pain is not usually a prominent symptom in gunshot wounds, and may be so slight that the patient often does not appreciate that he has been injured.

Hemorrhage.—Primary hemorrhage from gunshot wounds is not often excessive unless a large vessel has been wounded, so that if free bleeding occurs from such a wound it is well to enlarge the wound and search for the source of the bleeding, and when found the injured vessel should be secured by two ligatures applied upon its distal and proximal ends.

Secondary hemorrhage is apt to occur in gunshot wounds if large vessels have been contused and their vitality impaired, and if infection or sloughing of the tissues takes place. If the wound remains aseptic the risks of secondary hemorrhage are much diminished.

Powder Burns.—These may be received from the explosion of gunpowder or fireworks, from blasting accidents, or from the discharge of powder from guns at close range. The wounds resulting from these injuries usually present a certain amount of laceration of the tissues in conjunction with burns. The surface is blackened, and contains numerous black points caused by particles of unburnt powder which have been driven into the skin and cellular tissue. These wounds, as a rule, are not serious, unless they involve large surfaces of the body or involve the eyes: in the former case the symptoms following extensive burns may be presented.

Treatment.—The injured surface should be washed over with soap and water and then with a solution of bichloride or carbolic acid, and the little black particles of powder should be picked out of the tissues with the point of a needle or a bistoury; a gauze dressing should then be applied to the part. In spite of the greatest care in the removal of the particles of powder, a certain amount of tattooing of the tissues is apt to remain.

Wounds from Blasting Accidents.—Serious injuries often result from the premature explosion of blasts in which gunpowder, giant powder, or dynamite is used as the explosive. Persons employed in mines or quarries are apt to sustain these injuries, which result from masses or fragments

of rock, earth, and sand being thrown against the body with great violence. Many of these accidents result fatally at the time of the explosion; in other cases the patients may suffer from avulsion of the limbs or other portions of the body, from compound comminuted fractures, and from extensive lacerated wounds, the wounds being generally filled with fragments of stone, sand, or earth; at the same time the tissues often present extensive powder-burns. If death does not result immediately from the accident, shock or hemorrhage may in a few hours bring about a fatal termination.

Treatment.—The first indication in the treatment of these wounds, if severe, is to control hemorrhage and bring about reaction from the shock, which is usually well marked. If the extremities be so injured that amputation is necessary, as soon as reaction has occurred this should be performed. Extensive lacerated and contused wounds in these injuries are generally filled with fragments of stones, sand, and earth, so that it is a difficult matter to cleanse them: this can best be accomplished by using a stream of water and washing out the foreign matter as far as possible, removing it also by the use of forceps and curette. When satisfactorily cleansed, they should be dressed as lacerated and contused wounds, and the same caution observed as to the non-introduction of sutures.

Gunshot Wounds from Small Shot.—These wounds vary in severity with the size and number of the shot inflicting the injury and with the distance at which the charge is received. Small shot at long range produce slight injuries, unless a tender organ, such as the eye, be penetrated, which may result in its destruction, or an important vein or artery be injured, and usually present a number of distinct wounds from the scattering of the charge; the shot may simply penetrate the skin, or may involve the deeper tissues, or a few shot may penetrate the walls of the chest or the abdomen. On the other hand, if the charge of small shot is received at close range, its action upon the tissues resembles that of a bullet, and extensive laceration of skin, muscles, fasciæ, vessels, and nerves, as well as comminution of the bone, may result. We have seen wounds produced by charges of No. 10 shot at close range, in which an opening several inches in diameter was made through the tissues, the soft parts and the bones being carried away in the line of the wound. Portions of the scalp and skull, or of the face, chest, abdomen, or extremities, may also be torn away. A number of such cases of wounds of the extremities have come under our observation in which primary amputation was required.

Wounds produced by larger-sized shot, such as No. 1, BB, or buckshot, are often very serious injuries, even if received at a much longer range: here the bones may be fractured or contused, important vessels may be injured, or the cavities of the body may be penetrated and their contained viscera injured.

Treatment.—If the skin has been penetrated by small shot, the surface of the skin should be sterilized, and if any of the shot can be felt they should be picked out with the point of a bistoury and the wounds covered with a gauze dressing. If the shot wounds be upon the face, where a gauze dressing cannot well be applied, each little puncture may be covered with a scab of gauze and iodoform collodion. Shot which have entered more

deeply into the tissues usually become encysted and produce no subsequent trouble. If a few shot have punctured the walls of the abdomen or the chest, the external wounds should be sterilized and dressed with gauze and iodoform collodion or with a gauze dressing, and no attempt should be made to remove them; the only indication for enlarging the wounds would be the development of symptoms of concealed hemorrhage or inflammation. The patient should be put at rest for a few days and watched for the development of inflammatory symptoms. We were impressed with the fact that the viscera will tolerate the presence of shot by a post-mortem examination of a man whose body was covered with cicatrices of small shot wounds, in whose liver were found embedded many encysted bird-shot, apparently having produced no trouble.

Extensive wounds from small shot at close range, if they involve the extremities and have lacerated the soft parts extensively and comminuted the bones, usually require amputation, especially if the main arteries have been injured, but if the bones and arteries are not injured, even though the skin, fasciæ, and muscles have been extensively lacerated, it may be possible to save the part, and the wound should be sterilized and dressed with a bichloride gauze dressing, or may be treated by antiseptic irrigation until a healthy granulating surface is present. In extensive lacerations following gunshot wounds of the scalp and skull or the cavity of the chest or the abdomen, or if a solid viscus, such as the liver, be injured, the wound should be sterilized and loosely packed with iodoform gauze; the same treatment should be applied to wounds involving the lung. If the stomach or intestines be exposed and lacerated, attempts should be made to bring the edges of the visceral wound together with sutures, and the external wound should then be loosely packed with iodoform gauze. If the internal wound cannot be treated in this way it may be allowed to remain open, in the hope of a fistula forming at this point, which may later be subjected to operative treatment. Although these wounds are very serious ones and usually terminate fatally in a short time, yet occasionally recovery follows.

Wounds produced by buckshot or large shot are so similar to those produced by pistol-balls that their treatment is practically the same.

The treatment of **joint** wounds from small shot varies with the extent of damage to the soft parts and the injury to the joint itself. When a few shot have simply entered the joint through separate wounds, these, with the surrounding skin, should be sterilized, the wound sealed with gauze and iodoform collodion, and the joint fixed upon a splint or immobilized in a plaster of Paris dressing, and if no inflammatory symptoms develop the patient may recover with a useful joint. If infection of the joint occurs, it should be opened and drained, and subsequent excision of the joint may be required.

Wounds from small shot injuring important **arteries** or **veins** may give rise to hemorrhage, which may require the exposure and ligation of the injured vessel, or may subsequently cause a traumatic aneurism or arteriovenous aneurism, necessitating the ligation of the artery, the opening of the sac, or the amputation of the limb if a vessel of the extremities is involved.

Bullet Wounds.—These wounds are inflicted by pistol-balls or by rifle-balls. Wounds from pistol-balls are most commonly seen in civil practice, and are inflicted with balls varying from twenty grains in weight to two hundred and forty grains. The size of the ball is usually designated according to the decimal part of an inch which makes its diameter: thus, a thirty-two-calibre ball is .32 of an inch in diameter.

Bullet wounds are rarely seen in civil practice, and formerly were inflicted by round or conoidal balls varying from .50 to .71 of an inch in diameter. The modern rifle employed in warfare carries a slender cylindro-ogival bullet about .30 of an inch in diameter, made of lead and antimony, with a covering of steel, copper, or nickel. The modern bullet has much greater velocity than the leaden bullet formerly used, and does not change its shape so readily. It also has greater penetrating power: the same ball may penetrate the bodies of a number of men, and is apt to pass through resisting tissues, like bone, rather than to comminute them, as was the case with the conoidal leaden ball; and it is more likely to divide blood-vessels, nerves, and tendons. Primary hemorrhage is therefore likely to be more common and more fatal in wounds produced by the modern bullet than in those resulting from the old round or conoidal leaden bullet.

According to Connor, the modern rifle-ball in the early and late portions of its flight—that is, within three hundred to five hundred yards and beyond eighteen hundred or two thousand yards—is more destructive than the rifle-balls previously used, but in the intermediate distance the damage done is less, which is explained by the lateral swing of the ball before its axial rotation is thoroughly established and the swing which again occurs after its velocity becomes diminished. The great destruction produced at short range constitutes a *zone of explosive action*, the middle region is *the zone of penetration*, and beyond this part, where the velocity of the missile is diminished, is the *zone of contusion*. The most marked explosive action of the modern rifle-ball is seen in tissues rich in fluid contained in comparatively unyielding walls, where hydrodynamic pressure may be strongly exerted, as seen in wounds of the brain, viscera of the abdomen, and the hollow viscera filled with fluid or semi-fluid contents.

In wounds from rifle-balls, as in those from small shot, the range at which the injury is inflicted is an important factor in determining the gravity of the wound, as is also the location of the injury. A ball wound of muscles of the thigh or the arm, if no important vessels or nerves are injured and the wound is not infected, is usually not a serious injury, while one of the brain, or of the pleural cavity or the abdomen, or of a large joint, may be most serious in its consequences. A ball which enters the tissues may itself be infected, or may carry infection into the tissues from the skin or clothing. It may also, from its being in close relation to important structures, cause constant irritation until its removal is accomplished. On the other hand, as is also the case with small shot, the ball may become encysted and cause no trouble. From the fact that a ball embedded in the tissues may produce irritation or by subsequent change of position may cause trouble, it is considered wise, when it is possible, to locate and remove it.

When a ball strikes a *bone* it may perforate it or may cause fissuring or

comminution of the bone. The treatment of gunshot fracture will be considered under fractures; bullet wounds penetrating the chest, the abdomen, or the skull, and those involving the joints, will be considered under Injuries of Special Parts.

Treatment.—In a flesh wound produced by a bullet, where the ball has passed through the tissues and escaped, the skin surrounding the wound should be sterilized by washing with soap and water and with bichloride solution, and if there is no evidence that important vessels have been injured, as shown by the small amount of bleeding, the wound should be dressed with a gauze dressing. If, however, the ball remains in the tissues, and can be located without difficulty by palpation, or with the finger or a probe introduced into the wound, it should be removed, and the wound dressed as previously described. If there be free bleeding from the wound, it should be enlarged and the injured vessel sought for and ligated.

Large Shot or Shell Wounds.—These very serious injuries are met with only in military practice, and produce extensive lacerated and contused wounds, and often the destruction of considerable portions of the body. The injuries resulting from blasting accidents seen in civil practice often closely resemble those produced by the explosion of shells. Many of these injuries are fatal at the time of their infliction, particularly if the trunk or the head is involved. If the extremities, however, are involved, the patient may survive the injury, although amputation may be required. Extensive laceration by large shot or fragments of shells may be followed by gangrene and secondary hemorrhage, and either of these causes may bring about a fatal termination.

Treatment.—If shock is a prominent symptom, its treatment deserves the first attention; the dressing of the wound is that of a lacerated or contused wound, and if amputation is required it should be done as soon as the reaction from shock has taken place. In shell wounds any foreign bodies present in the wound should be removed, the wound irrigated with a 1 to 2000 bichloride solution, a drainage-tube introduced, and a gauze dressing applied.

Complications following such wounds, as gangrene and secondary hemorrhage, should be treated as described under the treatment of these affections arising from other causes.

Gunshot Wounds of Special Tissues.—Skin.—The skin in gunshot injuries may be contused, lacerated, or penetrated, according to the velocity of the ball and the angle at which it strikes. In the case of balls moving with little velocity the elasticity of the skin may prevent its laceration, although the subcutaneous tissues may be severely contused or crushed. The wound in the skin is apt to be small, so that drainage from the deeper parts of the wound is not free, and if suppuration occurs it may be necessary to enlarge the wound to provide free drainage.

Fasciæ.—Wounds of the fasciæ produced by modern balls of high velocity result in perforation or separation of the fibres of the fasciæ, the wounds contracting after the passage of the ball and leaving little opening for drainage.

Muscles and Tendons.—Gunshot wounds of muscles are not usually attended with extensive destruction of the tissue except in the immediate line of the passage of the ball. Gunshot wounds of tendons may cause their division or perforation. If the ball is moving at high velocity it is not likely that it will be deflected by the tendon.

Blood-Vessels.—Arteries and veins may be divided or perforated in gunshot injuries, the wound being followed by profuse or fatal hemorrhage. If, however, the walls of the vessels are contused, repair may take place, but if the wound becomes infected, subsequent sloughing of the vessel is likely to occur, giving rise to secondary hemorrhage. Simultaneous perforation of an artery and a vein may give rise to an arterio-venous aneurism.

Nerves.—In gunshot wounds nerves may be completely or incompletely divided or contused, giving rise to pain or loss of motion or sensation in the parts supplied by the injured nerve, which may be followed by trophic changes. Neuralgia may also follow gunshot wounds of nerves from the involvement of the nerve-fibres in the cicatrix at the seat of injury or from the development of a neuroma. Nerve-trunks are more likely to escape injury than blood-vessels of corresponding size.

BURNS AND SCALDS.

A burn represents the destructive effect upon the tissues produced by contact with a flame, radiated heat, or heated substances. **A scald** represents a corresponding effect produced by hot liquids or steam. In a burn the superficial hairs are scorched or burned off, while in a scald they are not changed in appearance but may fall out later. Concentrated acids and alkalies, either solid or liquid, applied to the tissues, produce a condition very similar to that resulting from burns and scalds. Burns are apt to be more circumscribed and deeper than scalds; in scalds, from the fact that hot fluids are rapidly diffused over the surface by saturation of the clothing, the injury is likely to be more superficial. Burns and scalds may involve not only the skin and subcutaneous tissues, but also the mucous membrane, especially that of the mouth, pharynx, nose, and conjunctiva. Scalds or burns of the mouth and epiglottis may occur from the inhalation of steam or hot gases.

The effects of burns and scalds upon the tissues depend upon the actual temperature of the heated body or fluid and the duration of its application. The instantaneous contact of a splash of molten metal will produce a superficial burn, while a few seconds' contact with the same substance will produce deep destruction of the tissues. The conditions resulting from burns and scalds are clinically so nearly alike that they may be considered together.

Classification.—Dupuytren's classification of burns in six degrees, according to the extent of injury inflicted, is very generally employed; but we are inclined to think a more practical classification is that of Morton, who divides burns and scalds into three degrees or classes: *first*, those which present hyperæmia or erythematous inflammation of the skin without vesication; *second*, those in which there is inflammation of the skin with

the formation of vesicles or bullæ; *third*, those in which there is more or less complete charring or destruction of the parts, skin, cellular tissue, muscles, and bone. These injuries may involve a small extent of tissue, or a considerable portion of the body.

The Constitutional Effects of Burns and Scalds.—These vary with the extent of surface involved and the degree of the burn or scald.

Shock is a marked symptom in all severe burns or scalds, and its development depends upon the position of the burn or scald and the extent of surface implicated. Superficial burns of great extent and those involving the trunk are accompanied by more marked shock than circumscribed burns with deep destruction of the tissues.

Patients suffering from extensive burns have, as a rule, little pain, but often complain of feeling cold, and may have a severe chill. They soon become comatose, and death results from cerebral and visceral congestion. If reaction occurs, the temperature rises to a high point and inflammation of the injured tissue develops, which may terminate in suppuration or gangrene. Albumin is usually present in the urine in this stage of burns and scalds.

Mortality.—The mortality following extensive burns or scalds is very high; according to Durham, if one-half of the surface of the body is burned or scalded, even superficially, death usually results. Nussbaum states that recovery is rare if a third of the surface of the body is superficially burned or scalded. The majority of cases of severe or extensive burns die of shock within twenty-four hours; that is, before reaction is established. If reaction is established, many cases die at a later period, of exhaustion following profuse suppuration, septicæmia, pyæmia, or secondary hemorrhage. Gastro-intestinal inflammation with vomiting and bloody stools may cause a fatal termination, as well as perforating *duodenal* ulcer, though the latter is certainly a very rare complication following burns or scalds, for in the post-mortem examinations of one hundred and thirty-eight patients dying of burns and scalds in St. Bartholomew's Hospital, only three cases showed intestinal lesions. Burns and scalds are very fatal during the period of infancy and childhood, and in this class of patients death usually results from shock. Œdema of the glottis is a dangerous complication of burns or scalds of the mouth in children, and is caused by inhalation of hot air or of steam in attempting to drink from the spout of a tea-kettle.

Treatment.—The treatment of burns and scalds of the *first* degree consists in the application of bicarbonate of sodium; lint saturated with this solution is wrapped around the part for a few hours, and very quickly relieves the pain. This dressing may be followed by the application of unguentum petrolatum or unguentum zinci oxidi. If the burn or scald is extensive, shock may be present, and should be treated upon general principles. This variety of burn leaves no scar. In the treatment of extensive burns or scalds of the *second* or *third* degree, pain and shock should receive the first attention. If pain is marked, it should be relieved by the administration of morphine hypodermically, and the treatment of shock, which is usually present, requires the most careful attention. The patient should be covered warmly and surrounded by hot water cans or bottles, and

be given aromatic spirit of ammonia, ♏xxx, diluted, or carbonate of ammonium, gr. v, at short intervals; he should also be given an enema of whiskey, f℥i, diluted, and strychnine should be administered in $\frac{1}{30}$ to $\frac{1}{60}$ grain doses hypodermically. In dressing such wounds, the clothing should be carefully removed or cut away, so as not to tear or injure the vesicles or blebs. If a large extent of surface is injured, it should be dressed a little at a time, so as not to expose the whole of it to the air for any considerable time. Recent burns or scalds are sometimes aseptic wounds, and if they can be dressed so as to preserve this condition healing should be rapid and unattended with complications. Blebs or vesicles should be punctured with the point of a knife, to allow their contents to escape, and the epidermis should not be removed, as it serves to protect the denuded papillæ until their surface is again covered with epithelium. If, however, the injury has been received some time before it comes under the care of the surgeon, the surface may be irrigated with a 1 to 4000 bichloride solution, freely dusted with powdered boric acid, and covered with a few layers of sterilized gauze and cotton. If a moist dressing is preferred, the injured surface may be covered with gauze moistened with boro-salicylic solution and covered with oiled silk or muslin. If it is considered desirable to apply an antiseptic dressing, this may be done by first irrigating the surface of the burn or scald, then covering it with sterilized protective, and over this applying a number of layers of bichloride gauze and cotton. When dry dressings are used they should be changed as infrequently as possible. The application of bichloride or of carbolized or iodoform gauze to the raw surface is not to be advised, as it may be followed by toxic effects. If sloughing of the tissues occurs, the dry dressings should be replaced by moist dressings of boro-salicylic solution, and when the sloughs have separated the granulating surface should be dressed with boric ointment. The application of a solution of nitrate of silver, gr. v to water f℥i, will have a stimulating action upon the granulations. The constant warm bath has been employed in the treatment of burns, especially in Germany: it is valuable in preventing sepsis, and is said to have very materially diminished the mortality. The bath should be of a temperature of 100° F. (38.8° C.), and the burned or scalded part should be kept in this bath for some days, until the sloughs have separated and a granulating surface is present. This method seems especially applicable to cases of burns or scalds of the extremities, but has also been used in cases of similar injuries of the trunk, when the whole body has been kept in the bath for a number of consecutive days and nights. When large healthy granulating surfaces are left after the separation of sloughs, much time may be saved in the healing, and the resulting deformity from cicatricial contraction may be greatly diminished, by employing some form of skin-grafting, such as Thiersch's method or the transplantation of skin-flaps. The use of splints, extension apparatus, and position may do much to obviate deformity after burns, and it is well to remember that these appliances should be continued for a considerable time after the ulcerated surfaces are completely healed, for the contraction is apt to be active for some months.

The *treatment* of burns or scalds involving the mucous membrane of the

mouth consists in the use of antiseptic washes, and here subsequent ulceration and contraction may interfere with the motion of the jaw.

The *treatment* of œdema of the glottis following burns or scalds of the mouth or pharynx consists in early scarification of the epiglottis as soon as the dyspnœa is marked, and if this is not quickly followed by relief, tracheotomy or intubation should be performed. Tracheotomy is, we think, the better operation, as the œdematous condition of the epiglottis interferes with the entrance of air into the intubation tube.

Sunburn.—Exposure to the sun produces upon exposed parts a condition of the superficial layer of the skin corresponding to a burn of the first degree; if the skin be delicate and the exposure prolonged, dermatitis with vesication may occur.

The principal symptoms are swelling, redness, and burning pain. If a large surface of the body is involved, sunburn may be followed by a fatal result, as is the case with burns of the first degree.

Treatment.—If the surface be covered with lint saturated with soda solution, followed by the application of vaseline, or of a lotion composed of oil of almond and bismuth, the pain will be relieved, and the inflammation quickly subside. Exfoliation of the superficial layers of the epidermis is apt to occur.

EFFECTS OF COLD.

The constitutional effects of prolonged exposure to cold are manifested by numbness, drowsiness, indisposition to move, a tendency to sleep, slow respiration and feeble pulse, coma, and death. The causes of death from exposure to cold vary with the intensity of the cold, the length of the exposure, and the constitutional condition of the subject. A person suffering from hunger or fatigue, or one in a debilitated condition, will be much less able to resist exposure to cold than one in whom different conditions obtain. In this climate death from exposure to cold is most frequently seen in intoxicated persons. Sudden exposure to intense cold may produce death by cerebral anæmia, while prolonged exposure may produce the same result by cerebral congestion. After exposure to severe cold, if the patient is suddenly subjected to warmth, death may result from embolism.

Treatment.—In the treatment of a person who exhibits the constitutional effects of cold, care should be taken that reaction does not occur too rapidly. The patient should be placed in a cold room and rubbed with ice and snow, and this rubbing should be followed by friction of the surface of the body with rough towels; if the respiration is feeble, artificial respiration should be resorted to, and stimulants, such as aromatic spirit of ammonia and whiskey, should be cautiously given by the mouth or by enema, the object being to bring about gradual reaction, and when this has occurred the patient should be covered with woollen blankets, and stimulants cautiously administered until reaction is complete.

Chilblain, or Pernio.—This is a condition produced by exposure to cold, and results from a vaso-motor paralysis, producing intense congestion of the parts. The portions of the body usually affected are the toes, feet, heels, fingers, face, ears, and nose. The parts become deeply congested and

swollen, and are the seat of intense itching and burning, and in serious cases blebs may form upon the surface. The sudden application of heat after exposure to cold is apt to cause rapid development of the affection. A person who has once suffered from chilblain is liable to suffer from a recurrence of the affection upon exposure to even a moderate degree of cold.

Treatment.—The prophylactic treatment of chilblain consists in bringing about very gradual reaction: to accomplish this, the part which has been exposed to cold should be rubbed with snow, or placed in cold water, or have a cold water dressing applied. The part, after reaction has been established, should be frequently painted over with a solution of nitrate of silver (gr. v to ʒi) and covered with raw cotton. A very satisfactory application in these cases is an ointment of ichthyol (ichthyol, ʒij; lanolin, ʒvi); this should be spread upon lint and laid over the parts. If blebs form, they should be punctured to allow the fluid to escape. The itching which often remains after chilblain may be relieved by rubbing the parts with camphorated soap liniment or with compound resin cerate.

Frost-Bite.—This condition represents the more serious effects resulting from sudden or prolonged exposure to cold, and is caused by the abstraction of heat. The parts of the body most frequently found to suffer from this affection are the feet, hands, nose, and ears, although the limbs may also be involved. The parts may be so completely frozen that upon thawing they are found to be absolutely dead, or their vitality may be so much impaired by the cold that when reaction takes place inflammation and strangulation of the tissues occur, producing gangrene.

Symptoms.—The part becomes numb and sensation is gradually lost, and it presents a white, blanched appearance; if completely frozen, in a short time discoloration and swelling follow the primary blanching. If the part is not completely frozen, and reaction is rapid, it becomes purple, swollen, and painful, and blebs may form; sensation is lost, the skin becomes mottled, and the tissues rapidly pass into a condition of moist gangrene.

Treatment.—In all cases of severe frost-bite, even when the part appears to be hopelessly frozen, treatment should be instituted to bring about moderate reaction. The part should be placed in cold water or covered with cloths wrung out of cold water, or cold water irrigation should be employed. If it has been completely frozen, gangrene soon manifests itself, but if the tissues are only partially devitalized by the exposure to cold, and if the subsequent inflammatory reaction can be gradually brought about, gangrene may be averted or may develop to but a limited extent. The cold water dressings should be continued for some time after reaction has taken place, and if gangrene has occurred, they should not be discontinued until it is evident that the gangrene is limited by lines of demarcation and separation. When the gangrenous tissue has separated, the ulcer remaining should be treated on general principles; and in the case of gangrene of the extremities following frost-bite, complete or partial amputation of the part should be practised as soon as the lines of demarcation and separation are well established.

INJURIES FROM ELECTRICITY.

Since the very extensive introduction of electricity in the arts, injuries from contact with heavily charged wires are of frequent occurrence. In such accidents, if the current be a strong one, death may be instantaneous, or the patient may be knocked down, become unconscious, and present severe burns at the point of contact, then regain consciousness, and subsequently suffer from numbness in the extremities, traumatic neuroses, and in rare cases true paralysis. If the skin be dry at the time the current is received there will be more burning, less penetration and less shock, and less danger of death. It is generally admitted that alternating currents are more dangerous than continuous currents; a continuous current of one thousand volts is not apt to be followed by serious consequences, whereas an alternating current of the same strength is likely to produce death.

We recently saw a young man who received a severe shock while holding an iron plate which came in contact with a trolley-wire. He was knocked down, and became unconscious for a few minutes; when he recovered consciousness he complained of a sense of constriction in his chest and difficulty in breathing, and of numbness in his arms. These symptoms passed off in a few hours, and he experienced no subsequent evil effects.

Some difference of opinion exists as to the cause of death after exposure to strong currents. Van Gieson insists that microscopic examination shows nothing characteristic except burns. The heart and respiration generally stop simultaneously. Hedley attributes death to asphyxia. The blood is usually dark-colored and fluid, rigor mortis is well marked, and the internal organs may show punctate hemorrhages. Hedley thinks that in strong alternating currents death is caused by destruction of the tissues, or by arrest of respiration producing asphyxia.

Treatment.—Unfortunately, in many cases where strong currents have been received, death is instantaneous from arrest of cardiac and respiratory action, but in all cases it is well to institute prompt treatment. Hedley mentions a case of apparent death in a man who received an alternating current of four thousand five hundred volts short-circuited through his body for many minutes, who showed no signs of life for thirty minutes. In this case, after the employment of Laborde's method of artificial respiration for some time, normal respiratory action was restored and the patient recovered. Artificial respiration should be practised in all cases, and should be continued until it is certain that the patient is dead. At the same time strychnine should be used hypodermically, and friction applied to the surface of the body.

Lightning-Stroke.—A person struck by lightning may die instantaneously or be more or less deprived of consciousness for a time, and may suffer from burns superficial or deep. Upon regaining consciousness the patient may complain of disturbance of vision, and may suffer from paralysis of the nerves of motion or sensation; paralysis of the lower limbs is said to be more common than that of the upper limbs.

Treatment.—The treatment of the stage of shock following lightning-stroke consists in the application of external heat, the employment of artifi-

cial respiration, and the administration of stimulants. If burns exist upon the surface of the body, they should be treated like burns arising from other causes. If paralysis of special or general nerves persists some time after recovery from the immediate effects of the shock, the use of galvanism and the administration of strychnine may be followed by good results.

DISEASES OF CICATRICES.

When the edges of wounds have been neatly approximated, and healing by first intention has taken place, it is unusual for any trouble to develop in the cicatrix, except keloid, which may occur even in such cases. The principal affections of cicatrices are *weak* cicatrix, which has a constant tendency to break down or ulcerate, *painful* cicatrix, *keloid*, *malignant disease* of the cicatrix, *depressed* cicatrix, and *contracting* cicatrix.

Weak Cicatrix.—This form of cicatrix has a tendency to break down or ulcerate near its centre, and is usually seen in cicatrices following extensive wounds, burns, or scalds when a large amount of skin has been destroyed, and the same tendency may be observed in cicatrices which are adherent to bone. Cicatrices in tuberculous subjects are also apt to break down because of tubercular infection, even when primary healing has been satisfactory. The surgeon in treating wounds and burns should direct his attention to the diminution of the extent of the scar, knowing that in any large cicatrix the vitality of the tissues at its centre is small, and that it is therefore liable to break down or ulcerate. The amount of scar-tissue resulting from the repair of extensive wounds may be diminished by the use of skin-grafting, or by the sliding of flaps of healthy skin and connective tissue.

Treatment.—When a cicatrix has a tendency to break down, the diseased portion should be dissected out and skin-grafts applied to the raw surface, or healthy skin should be transplanted to cover its surface. When a weak cicatrix is adherent to bone, the separation of the cicatrix with a tenotome, or the removal of a portion of the bone, will often be followed by improvement in its condition.

Painful Cicatrix.—This condition results from the implication of a nerve in the cicatrix, producing a certain amount of neuritis from the contracting fibrous tissue of the scar. When a painful cicatrix is small or of moderate size, the best treatment consists in dissecting it out and filling the resulting gap by sliding flaps of skin. If, however, the cicatrix be too extensive for this operation, relief from pain may be afforded by performing neurotomy, neurectomy, or nerve-stretching upon the nerves entering the cicatrix.

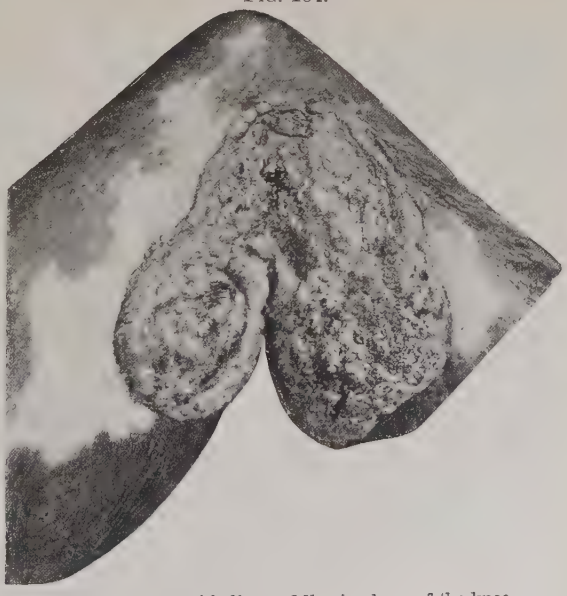
Keloid.—This is a form of disease in cicatrices which is characterized by hypertrophy of the scar-tissue, and is seen especially in the scars following burns, but may also develop in those following other varieties of wounds. It was formerly the custom to divide these growths into the *true* and the *false*, according as the keloid had its origin in the normal skin or in a pre-existing scar, but this distinction is not now recognized. The scar becomes thickened and irregular, hard projections form upon its surface, the surface of the hypertrophied tissue often presents dilated veins, and claw-like processes

may extend to the adjacent skin. Keloid may be the seat of neuralgic pain, but is usually not painful, and is more apt to be accompanied by intense itching; it may ulcerate and give rise to bleeding. Scars in certain individuals are especially apt to develop keloid. We have seen keloid develop in such cases after small incised wounds and after the bites of insects. It is said to be more common in persons of a tuberculous diathesis. Keloid is much more common in negroes than in whites. (See also under Tumors.)

Treatment.—Excision of keloid, although it would seem the most natural method of dealing with the growth, has proved unsatisfactory, as the disease usually returns in the new cicatrix, and the resulting growth is often larger than the original one. When it is possible to dissect out a mass of keloid and approximate the edges of healthy skin, the resulting deformity may be less marked, even if the disease returns in the new cicatrix. As a rule, however, it is better to apply some treatment which diminishes the blood-supply of the growth, and this may be accomplished by the use of pressure applied by compresses and straps, or by elastic pressure. Warren recommends the following application to be painted upon the surface of the growth: plumbi acetatis, ʒi; collodion, ʒv. This treatment we have employed in keloids of recent development with apparently good results. Scarification in many cases is followed by improvement, and electrolysis has recently been employed with success. Although the growth is unsightly, and when recent may cause pain and itching, the fact should not be lost sight of that in time there is a tendency to atrophy, and that it may become much less prominent. In tuberculous subjects who present keloid growths the use of iodide of iron and cod-liver oil may be followed by benefit.

Warty Ulcer, or Epithelioma, of Cicatrices.—This is a form of ulceration, very persistent in its character, which is occasionally seen in old cicatrices of burns or gunshot wounds. The appearance of epitheliomatous degeneration of the cicatrix of a burn of the knee in a negro woman, associated with contraction of the knee of thirty years' duration, is well shown in Fig. 164. Some of these ulcers are non-malignant, being of a fibrocellular character, while others present the structure of true epithelioma; the ulcer is covered with small granulations having a papillary appearance like condylo-

Fig. 164.



Warty ulcer, or epithelioma, following burn of the knee.

mata, which often project above the surface of the surrounding tissue. The ulcer may cause little discomfort for a long time, or it may gradually increase in size, become the seat of intense pain, and be accompanied by free and offensive discharge. A few cases of this affection have come under our observation in cicatrices of gunshot wounds or burns of many years' duration. A warty ulcer of the leg in the cicatrix of a gunshot wound received during the war of the rebellion is shown in Fig. 165.

Fig. 165.

Warty ulcer, or epithelioma, developing in cicatrix of gunshot injury.

Treatment.—The treatment of this affection consists in dissecting out the ulcer completely when it is possible, and in filling the gap by sliding flaps of skin; in other positions, such as the extremities, when the bones may be involved and the growth cannot be completely removed, amputation should be resorted to.

Depressed Cicatrix.—This form of cicatrix is very common after the healing of wounds involving bone or the soft tissues when there has been a loss of substance. The best examples of depressed cicatrices are seen after the healing of wounds from operations for necrosis and caries, and in those cicatrices observed after suppuration of the cervical lymphatic glands. As a rule, these cicatrices require no treatment except when upon exposed surfaces of the body, as the face or the neck, where their presence causes disfigurement.

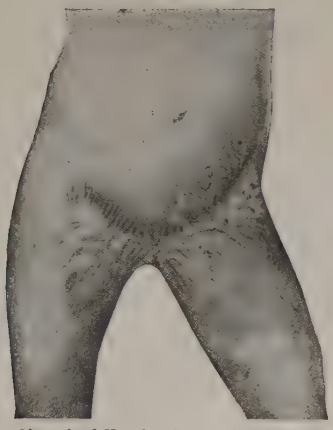
Treatment.—When the depressed cicatrix is small we have employed with good results the operation devised by Adams, which consists in introducing a tenotome under the cicatrix from one edge and dissecting it loose from its subcutaneous attachments; two harelip pins are then passed at right angles to each other through the skin, and are passed under the loosened cicatrix to hold it upon a level with the surrounding skin. An antiseptic dressing should next be applied, and at the end of three or four days the pins are removed, at which time a blood-clot has filled up the cavity under the cicatrix, which, becoming organized, prevents subsequent depression of the scar.

In extensive and deeply depressed cicatrices connected with bone the deformity may be much relieved by making a longitudinal incision through the tissues at the deepest portion of the cicatrix, dissecting each flap loose from the bone, and then filling the cavity with bone chips and bringing the edges of the flaps together over them with sutures. In an extensive and deep cicatrix following the removal of a cyst of the lower jaw we succeeded by this operation in relieving the disfigurement very satisfactorily.

Contracting Cicatrix.—The most troublesome deformities which are brought to the surgeon for correction are those resulting from the contraction of cicatrices of burns and scalds. The deformities in these cases are

due not only to a loss of tissue from destruction by the burn or scald, but also to the contraction and cicatrization of the reparative material itself. The cicatrices following burns and scalds may also assume a keloid character; this change is more common in children than in adults. The contraction

Fig. 166.



Cicatrix following burn of abdomen and thighs.

Fig. 167.

The same case after a plastic operation.

following burns or scalds of the face may cause ankylosis of the jaw; those of the anterior part of the neck and chest may cause the chin to be drawn down to the sternum, or lateral distortion of the neck may take place; the joints may be immovably flexed, or the arm may be bound down to the chest so that it is practically useless, or the mouth, eyelids, or ears may be distorted. The contraction of the tissues following a burn of the abdomen and upper part of the thighs in a girl of ten years, in whom a hood was formed in front of the external genitals, is shown in Fig. 166; the condition of this patient after operation is shown in Fig. 167. The deformity following burns of the extremities often seriously interferes with the function of the joints. The deformity of the hand following a burn of the hand and wrist is well shown in Fig. 168.

Fig. 168.

Contraction of hand from burn. (Agnew.)

Treatment.—The use of splints and extension in the treatment of burns where contraction is liable to occur before the wounds have healed has been previously mentioned, and the same appliances should be made use of in the case of recently healed burns with contracted cicatrices, for while the scar-tissue is soft and pliable it is often possible to diminish the amount of contraction. If, however, the skin and connective tissue have been destroyed, it is generally impossible to correct the deformity except by a plastic operation.

In operations upon contracted cicatrices it is sometimes necessary to use a part of the scar-tissue, and therefore it is well not to operate until con-

traction has ceased, which will be often as long as six months or a year after the healing of the wound; the vitality of the scar-tissue will be usually at this time so well established that it will not be likely to slough.

Fig. 169.

Operation for cicatrix at elbow. (Agnew.)

In correcting the deformities resulting from contracted cicatrices, skin-grafting, preferably by Thiersch's method or a plastic operation, may be resorted to. The first step in these operations is the division or freeing of the contracted cicatrix, so that the parts which are held in a faulty position can be brought as nearly as possible into the normal position. In dividing these tissues it is well to remember that, especially in contracting cicatrices about the joints, important nerves and vessels may be included in the cicatrix, and care should be taken not to injure them. Contraction at the elbow following burn or scald of the anterior surface and forearm may be relieved by making an incision on each side of the contracted tissue and dissecting up the triangular mass of cicatrized tissue, afterwards bringing together the edges of the incision in the skin with sutures. (Fig. 169.) A similar procedure may be adopted in cases of contraction of the knee from a cicatrix.

CHAPTER XI.

PLASTIC SURGERY.

This branch of surgery includes the operative procedures which are employed to repair defects in the various tissues of the body. The replacement of parts partly separated by injuries, as well as the readjustment of parts entirely severed, is also sometimes included under plastic surgery.

Plastic operations are divided into *heteroplastic* operations, in which the defect is repaired by tissue taken not from the individual in whom the defect exists, but from another individual or one of the lower animals, and *autoplastic* operations, in which the tissue to supply the defect is taken from the same individual.

Plastic operations may be required for the repair of congenital defects, such as harelip, cleft palate, or exstrophy of the bladder, for defects resulting from injuries or from the removal of tumors, or for the distortion and functional disturbance resulting from the contraction following injuries, burns, and ulceration consequent upon lupus and syphilis or other intractable forms of ulceration. These operations may be indicated for the restoration of function, as is seen in cases of harelip, cleft palate, or contractions about the joints. They are often indicated for cosmetic reasons, when they are employed to relieve deformities resulting from congenital defects, injuries, burns, or the abnormal development of certain parts of the body, as is seen in cases of hypertrophy of the nose, lips, and tongue, and of displacement or malformation of the ears. The tissue which is generally employed to repair defects is the skin with its subcutaneous tissue, or the superficial layers of the skin, as in skin-grafting, although other tissues, such as bone, bone chips, muscle, tendon, nerve, and mucous membrane, are sometimes used.

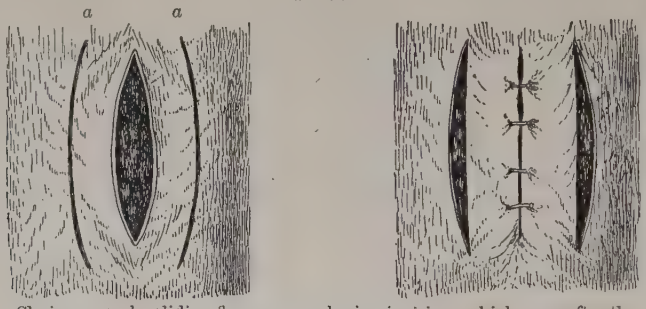
The elements which conduce most to success in plastic operations are rigid care as regards asepsis, perfect control of hemorrhage, since the interposition of a blood-clot may interfere with union, and avoidance of tension upon flaps, which can be secured by having the flaps of sufficient size. The flaps should be cut about one-third larger than the gap to be filled, to compensate for the subsequent shrinkage. A flap which is white in appearance after it has been transplanted is less likely to slough than one which is purple and congested; the latter is more apt to develop moist gangrene from venous obstruction.

Choice of Time for Plastic Operations.—This depends largely upon the affection for the relief of which the operation is performed: the condition of the parts and the patient's general condition in these cases often call for the exercise of the best surgical judgment. In congenital

defects, such as harelip, it is well to postpone the operation, if possible, for a few months after birth; while in cases of cleft palate the operation should be deferred until the child is two or three years of age; and neither operation should be undertaken if the child is in poor physical condition. Where plastic operations are undertaken for the deformity resulting from the ulceration of lupus or syphilis, the patient should have had a prolonged course of specific treatment, and the ulcer should be firmly cicatrized before the operation is performed.

Where plastic operations are performed to fill a gap left by the removal of a tumor or of a portion of a bone or nerve, the flaps may be fashioned and approximated or the piece of bone or nerve introduced into the gap at the time of operation. Immediate suture of completely severed parts should also be practised even if some little time has elapsed since the injury. A suficient number of successful cases have been reported to render this procedure advisable.

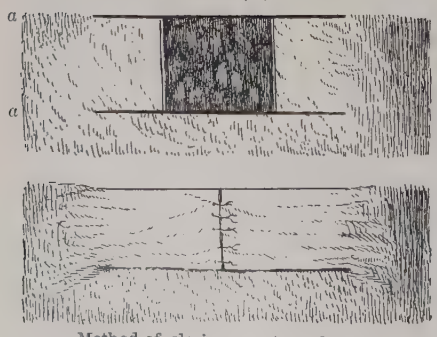
Fig. 170.



Closing a gap by sliding flaps: *a*, *a*, relaxing incisions which gape after the flaps are brought together.

Methods used in Plastic Surgery.—In closing gaps, the tissues in the immediate vicinity may be utilized by dissecting them loose and then stretching or sliding them, and, if the gap to be filled is a considerable one, relaxing incisions (*a*, *a*) may be made, as shown in Fig. 170, the gaps of these incisions being allowed to heal by granulation. In closing a rectangular gap in the tissues the method shown in Fig. 171 may be employed, the flaps being loosened on the lines *a*, *a*. A triangular gap may be closed by loosening and sliding the tissues according to Dieffenbach's method, the gaps at the ends of the incisions being allowed to heal by granulation. (Fig. 172.) Another very common method of closing a gap is to employ a flap with a pedicle, which may be brought from a distance and twisted upon itself, or the flap may be slid (Fig. 173), or may be everted and covered by lateral flaps which are slid and have their raw surface in contact with the raw surface of the inverted flap, as is

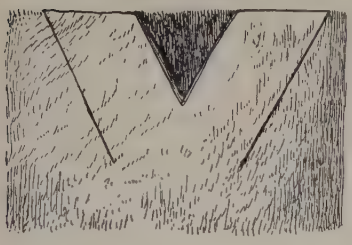
Fig. 171.

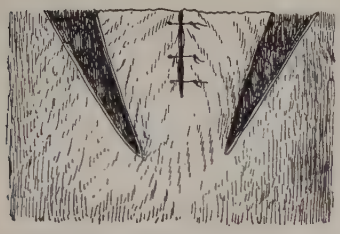


Method of closing a rectangular gap.

done in Wood's operation for exstrophy of the bladder. In cases where it is impossible completely to cover a large raw surface or ulcer, much time may be saved in the healing and contraction may be avoided by sliding a flap with a pedicle from each side of the wound or ulcer, and suturing them so as to form a bridge of tissue across the gap, as shown in Fig. 174.

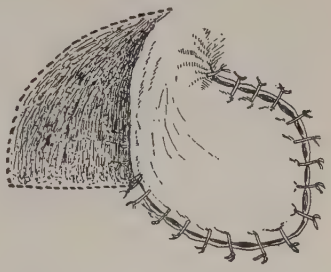
Fig. 172.





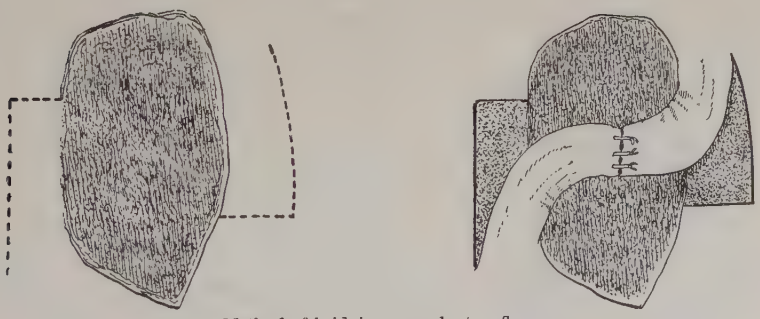
Method of closing a triangular gap.

Fig. 173.



Method of closing a gap by flap with a pedicle.

Fig. 174.



Method of bridging a gap by two flaps.

SKIN-GRAFTING.

Reverdin's Method.—This consists in applying to a granulating surface small flat pieces of epidermis; small grafts not larger than an eighth or a twelfth of an inch in diameter, including only the superficial epithelium of the skin, should be employed, being taken from the skin of a recently amputated limb, or from the skin of the patient himself, or from another subject. The grafts may be cut with a sharp scalpel or razor, and should be directly transferred to the granulating surface and placed with their raw surface in contact with the granulations. To insure success, the granulating surface should be in a healthy condition; if there is profuse discharge of pus from the surface the grafts are apt to be floated off, and the procedure is likely to fail. The use of antiseptics also prevents the successful taking of the grafts, and therefore in this procedure asepsis should be practised. In em-

ploying this method of skin-grafting, if there is purulent discharge upon the granulating surface it should be freely irrigated with normal salt solution, and a number of grafts should be applied to the granulating surface, after which the surface should be covered with a piece of sterilized protective or rubber tissue, a sterilized gauze and cotton dressing being applied over this and allowed to remain in place for a week. Upon the removal of the dressing at this time it will often be found that a portion of the outer layers of the grafts has been cast off, but usually sufficient epithelial structure remains, from which subsequent proliferation occurs, forming islands of epithelium upon the granulating surface. The part should be again dressed in the same manner, and at the end of two weeks the growth of epithelium at the site of the grafts is usually very marked, and the granulating surface soon becomes covered by epithelium.

Thiersch's Method.—This consists in covering the prepared granulating or raw surface with strips of skin consisting of the epidermal and papillary layers, from two to four centimetres wide and of variable length, which are cut from the skin of the patient or another individual, or from a recently amputated limb, with a sharp razor or scalpel. In cutting these strips the skin should be made tense at the point of removal, and this can be well accomplished by the use of McBurney's skin-stretching hooks. In employing this method of skin-grafting, the granulating surface should be first irrigated with warm salt solution, and the surface curetted, or the granulations may be shaved off with a sharp knife, the bleeding being arrested by the pressure of an aseptic compress. When the hemorrhage has been controlled the surface should again be irrigated and dried, the strips of skin placed upon the surface so as to cover its whole extent, and a piece of sterilized rubber tissue or protective and a sterilized gauze and cotton dressing applied. This dressing should not be removed for a week or more, and subsequent dressings should be made in the same manner. If at the end of a few days the grafts have a pink tint, it is a good sign, but if they are white, a large portion of the grafts will exfoliate, although, as in the case of small isolated grafts, enough epithelial cells may remain to form islands, from which proliferation of epithelium may occur. The result following skin-grafting of the orbit by this method is shown in Fig. 175. Perfect control of the bleeding is an important point, for if this is not accomplished the blood accumulates under the skin-grafts and separates them from the surface. The skin from the back or belly of a frog, or the hairless skin of young animals, may be used for grafting, and is applied with the same precautions and in the same way. Where skin-grafting is practised upon a fresh raw surface to fill a gap caused

Fig. 175.

Result of skin-grafting of orbit after removal of the eye and eyelids.

by the removal of a tumor, or a defect resulting from a plastic operation, the bleeding should be controlled and the grafts applied immediately. The raw surface left after the removal of the grafts should be covered by a dry aseptic dressing, and usually heals promptly.

Transplantation of Large Skin-Flaps.—Krause recommends in extensive granulating surfaces the transplantation of one or more large skin-flaps, the granulating surface being scraped or curetted, and the edges, if unhealthy, excised. The wound is irrigated with normal salt solution, and if bleeding is free it is controlled by the pressure of a sterilized gauze compress. The surface from which the flap is to be taken being shaved and thoroughly sterilized, a flap at least one-third larger than the surface to be covered is dissected up, including the epidermis and cutis. The flap is placed upon the raw surface, and is held firmly in contact with it by a compress of sterilized gauze, and a copious gauze and cotton dressing is next applied. This dressing is not disturbed for four or five days, and, when removed, if blebs have formed between the epidermis and the cutis they should be opened, and a similar dressing again applied. If the flap has retained its vitality at the end of a week, the case usually progresses favorably.

Transplantation of Mucous Membrane.—Transplantation of mucous membrane has been successfully accomplished in a few cases, but the results are less successful than those following skin-grafting, from the fact that it is practically impossible to maintain asepsis. Successful transplantation of mucous membrane has been accomplished in the conjunctiva, urethra, and mouth. The growths are taken from the mucous membrane of the mouth or from the mucous membrane of animals. The surface to which the graft of mucous membrane is to be applied is carefully freshened, and the graft is then placed upon it and secured by sutures.

Plastic operations upon *muscles*, *nerves*, and *tendons* are described under injuries of these tissues.

Plastic Operations upon Bone.—These may consist of osteoplastic resections, replacement of separated portions of bone, or bone-grafting.

Osteoplastic resection, which consists in separating or turning aside a portion of a bone with its periosteum, soft parts, and skin attached, is an operation sometimes employed for the exposure and removal of necrosed bone or tumors of bone, and is also practised upon the skull and the upper jaw to expose subjacent growths. In these operations great care should be exercised as regards asepsis, and when the bone with its soft parts attached is replaced, it should be sutured to the surrounding bone by the introduction of a few sutures into the bone as well as the soft parts.

Replacement of Bone Fragments.—Separated fragments of bone may be replaced, and if they are rendered aseptic may retain their vitality and again form vital attachments to the surrounding bone. In fractures of the long bones of the extremities, separated fragments may be replaced, where their loss would cause so much shortening that the limb would be useless; and the same procedure is practised in fractures of the skull, or after trephining of the skull, when the button removed by the trephine may be replaced. The trephine button or bone fragments should be placed in a

warm sterilized salt solution until the surgeon is ready to replace them. The fragments or trephine button may be simply laid upon the dura in the case of injuries of the skull, or may in the case of the long bones be drilled and sutured to the surrounding bone before they are covered by the soft parts.

Bone-Grafting.—This consists in splitting a portion of an adjacent bone, allowing it to retain its periosteal attachment, and turning it in and suturing it to the neighboring bone to fill a defect; or in the use of a portion of fresh bone from an amputated limb, or from one of the lower animals, and suturing it in place to the adjacent bones to fill the gap. In bone-grafting by this method the edges of the gap in the bone are freshened, and a portion of bone long enough to fill the gap is cut and sutured in position.

Senn's modification of bone-grafting consists in the use of decalcified bone plates or chips. The bone plate being cut to the size of the gap and fitted into it, it may be rendered additionally secure by the introduction of a few catgut or silk sutures. In the case of large defects, where bone plates are used, they should be perforated at a number of points, to provide for drainage. In bone-grafting with chips, the bone-cavity should be carefully sterilized and freshened, and should be loosely packed with bone chips. After the bone plates or chips have been introduced, the periosteum and soft parts should be closed over them by sutures of catgut or silk, or, if this is impossible by reason of a great loss of the soft parts, a tampon of iodoform gauze may be employed to keep the grafts in place. Detached portions of bone, or bone plates or chips, act only as a scaffolding for the production of new bone, and apparently never retain their vitality, disappearing slowly by absorption as new bone forms. In some cases they remain unabsorbed for a long time.

Here, as in other forms of bone-grafting, perfect asepsis of the cavity, of the plates or chips, and of the surrounding soft parts is essential to success.

Bone plates or **bone chips** are prepared as follows. The fresh tibia or femur of the ox, after the periosteum and medullary tissue have been removed, is split or sawed into pieces from one-half to one inch in length, which are then decalcified by being placed in a fifteen per cent. watery solution of hydrochloric acid and allowed to remain for three weeks, the solution being changed daily. At the end of this time they should be removed from the hydrochloric acid solution and thoroughly washed, cut into thin plates or strips and washed in a weak solution of caustic potash, and then placed in a 1 to 1000 mercuric bichloride solution for forty-eight hours. They may then be kept for use in a solution of 1 to 500 of bichloride in alcohol, or in a saturated solution of iodoform in ether. Before being used they are soaked in a 1 to 2000 bichloride solution, and subsequently in sterilized water.

CHAPTER XII.

ANÆSTHETICS.

General anæsthesia for surgical operations which are painful or which consume a considerable amount of time may be induced and maintained by the use of *nitrous oxide gas*, *ether*, *chloroform*, *ethyl bromide*, or *A. C. E. mixture*, while in minor operations, or those which consume little time, local anæsthesia, obtained by the use of *cold*, a spray of *ether*, *rhigolene*, or *ethyl chloride*, *cocaine* or *eucain hydrochlorate*, or Schleich's method of *infiltration anæsthesia*, may be employed.

LOCAL ANÆSTHESIA.

Cold.—Local anæsthesia may be produced by the application of cold, either by holding a piece of ice or a mixture of salt and ice in contact with the surface for one or two minutes; the part becomes blanched and insensitive.

Rhigolene or Ether Spray.—The application of a spray of rhigolene or ether to the surface of the body for a few minutes will produce a similar result as regards the production of anæsthesia.

Ethyl Chloride may also be used to produce local anæsthesia, and is conveniently furnished in glass tubes, one end of which is drawn out into a fine point and hermetically sealed, or provided with a fine metal tube with a screw cap; when required for use the end of the glass point is broken off or the metal cap is removed and a fine jet of ethyl is projected upon the surface, the warmth of the hand being sufficient to force the fluid from the tube.

Local anæsthesia produced by the various means mentioned may be made use of in minor surgical procedures, such as aspiration, the opening of abscesses, removal of foreign bodies from the tissues, and the removal of superficial tumors. As all these substances produce anæsthesia by cold, if the operation is one requiring considerable dissection, the application has to be repeated a number of times, and the vitality of the tissues may be so much impaired by the cold that primary union may not be obtained or sloughing may take place. For this reason we think it is wise to restrict their use to the production of anæsthesia for the opening of abscesses, exploratory puncture, or aspiration.

Cocaine Hydrochlorate.—Local anæsthesia may also be obtained by the employment of an aqueous solution of hydrochlorate of cocaine applied to mucous surfaces or injected into the tissues; it has no anæsthetic action when applied to the surface of the skin. When a solution of cocaine comes in contact with sensory nerve-endings an area of analgesia results from their temporary paralysis; it also produces a localized anæmia of the tissues from

vaso-motor constriction. The drug is used in solutions varying from one to twelve per cent. The solution should be freshly made with boiled water, or, if it is to be kept for any time, a little bichloride of mercury or salicylic acid should be added to preserve it. We rarely use solutions of cocaine of greater strength than from one to four per cent., and find that analgesia can be as satisfactorily obtained with these as with the stronger solutions, while by the employment of the weaker solutions the risk of toxic effects is much diminished. Death has followed the use of a twelve per cent. solution injected into the urethra, and we consider it a safe rule never to inject more than one or two grains of the drug into a mucous cavity at one time. Certain individuals have an idiosyncrasy for cocaine; children seem more susceptible to its constitutional effects than adults. In the former class of patients we have seen marked symptoms of cocaine-poisoning result from the application of a four per cent. solution to the nasal mucous membrane. The *toxic* effects of cocaine are manifested by headache, pallor, cold moist skin, feeble slow pulse, incoherent speech, nausea, vomiting, epileptiform attacks, dilated pupils, dyspnœa, and asphyxia. The *treatment* of cocaine-poisoning consists in rest in the recumbent posture, the use of ammonia, whiskey, or ether by hypodermic injection, and the employment of artificial respiration if the respiratory function is markedly disturbed.

In the production of anæsthesia of *mucous* surfaces the part may be brushed over with a one or two per cent. solution of cocaine, or pledgets of absorbent cotton may be saturated with the solution and held in contact with the part for a few minutes. It may be applied to the nasal mucous membrane by the use of a spray or by pledgets of cotton. In operations upon the *eye* a few drops of a two per cent. solution are dropped into the eye, and the application is repeated until the analgesia is complete. To produce analgesia of the *urethra* a drachm or two of a one per cent. solution is injected and allowed to remain from two to five minutes. The injection of cocaine into the *rectum* is not to be recommended, as its use here is often attended with danger, but if it is employed in this organ, or in the region of the anus, a one or two per cent. solution should be applied upon a pledget of absorbent cotton.

When it is desirable to produce analgesia of the skin or deeper tissue, it is necessary to inject the solution into the skin, cellular tissue, and subjacent tissues, and to avoid multiple punctures the needle is introduced at one point, and after injecting a certain amount of the solution it is partly withdrawn and thrust in another direction, this procedure being repeated until a circumscribed area of tissue has been injected at different points, when the needle is finally withdrawn. It is a safe rule not to employ more than one grain of cocaine hypodermically at one time. The electrolytic method with cocaine upon the positive pole has been highly recommended by some surgeons.

It is well, where it is possible, to cut off the circulation from the part to be operated upon by placing around it a rubber strap or tube, which prevents the rapid entrance of the drug into the circulation, and thus enables much larger quantities to be used with safety.

Cocaine-Anæsthesia is useful in minor surgical operations, such as the amputation of fingers or toes, circumcision, opening of abscesses, or removal of superficial tumors, and its utility is most marked in operations upon the eye and those upon the mucous membranes of the nose, throat, vagina, and urethra. Although major operations, such as removal of the breast, and amputations of the leg, arm, or thigh, have been performed under cocaine anæsthesia, we do not think its use is to be recommended in such cases. Its employment in minor operations upon children will not be found so satisfactory as general anæsthesia, for, in spite of the fact that the part may be rendered anæsthetic, they experience so much fright that it is impossible to restrain their movements.

Eucain Hydrochlorate.—This drug, which produces local anæsthesia in the same manner as cocaine hydrochlorate, has recently been employed. It is used as a local application to mucous surfaces and hypodermically in the deeper tissues to produce local anæsthesia.

It possesses the advantage over cocaine that it can be used in much larger quantities, as it is apparently free from toxic action. Kiessel states that two grammes (thirty grains) can be injected without the production of toxic symptoms. It is conveniently used in solutions of from two to ten per cent.

Infiltration Anæsthesia.—This method of producing local anæsthesia has recently been described and employed by Schleich. Liebreich has shown that the injection of water into the tissues in such a manner as to produce an artificial œdema will produce a temporary local anæsthesia. Schleich found that by combining a small amount of cocaine and morphine with a weak salt solution the period of anæsthesia was prolonged. The anæsthesia is produced in this method by the artificial ischæmia established by the tension and pressure to which the tissues are subjected, and by the direct action of the injected drugs upon the nerves. In employing this form of anæsthesia a weak solution of cocaine, morphine, and common salt is introduced into the tissues by means of a hypodermic syringe. The solution usually employed is made as follows: cocain. hydrochlor., gr. iss; morphinæ sulph., gr. $\frac{1}{2}$; sodii chloridi, gr. iij; aquæ, fʒiij, ʒiij. M.

The skin and the syringe should be sterilized, and the surface which is to be punctured by the needle may be rendered insensitive by the use of a spray of ether or ethyl chloride. The needle should be introduced into the skin and the fluid injected at different parts until wheals are raised. The injections should then be made into the deeper parts, until the whole area of tissue which is to be operated upon is thoroughly infiltrated with the solution. The resulting anæsthesia lasts for fifteen or twenty minutes.

Infiltration anæsthesia is employed in minor surgical procedures, such as the opening of abscesses, amputation of fingers, and removal of tumors, and it has also been employed satisfactorily in major surgical operations, such as herniotomy and amputations of the limbs.

Guaiacol may be used externally as an analgesic in neuralgia or in epididymitis, the part being painted with a solution of guaiacol, gr. xv, alcohol, fʒv. In epididymitis it is preferable to use an ointment of five parts of guaiacol to thirty parts of vaseline. It may also be used hypo-

dermically to produce local anæsthesia in minor operations, a one-tenth to one-twentieth solution in olive oil being employed. Its hypodermic use is not unattended with danger.

GENERAL ANÆSTHESIA.

General anæsthesia may be produced by the use of nitrous oxide gas, ether, chloroform, A. C. E. mixture, ethyl bromide, or other substances. The condition of general anæsthesia is one in which there is always some danger. Accidents may occur during the development or after the production of this condition, and the surgeon, and the assistant who administers the anæsthetic, should be mindful of this fact and watch the patient most carefully.

Choice of Anæsthetic.—In selecting an anæsthetic the most important considerations are its safety and its suitability for the individual case. Of the anæsthetics used to produce general anæsthesia, in point of safety nitrous oxide gas holds the first place, but unfortunately its use is restricted to cases in which only a few minutes' anæsthesia is required. Next in safety is ether, and next chloroform. Statistics show that the mortality following the administration of nitrous oxide gas is 1 to 5,250,000; of ether, 1 to 16,675; of chloroform, 1 to 3749. From these figures it will be seen that nitrous oxide gas is by far the safest anæsthetic; but it should be remembered that nitrous oxide is used only in trivial operations, while ether and chloroform are employed in the most serious surgical procedures, and that many of the deaths attributed to the anæsthetics may have been due to conditions resulting from the operations themselves.

Nitrous Oxide Gas.—This gas is administered for the purpose of producing anæsthesia of limited duration. The apparatus best suited for its administration consists of a cylinder of metal in which the gas is compressed; this is attached by a tube to a rubber bag, and to this bag is attached a mouth-piece provided with a double valve, which prevents the expired air from passing back into the bag. The flow of gas is regulated by a stopcock attached to the cylinder. In administering this anæsthetic the patient is usually placed in the sitting or recumbent posture, and after removing false teeth or foreign bodies from the mouth, the jaws are held apart by a gag or a cork or piece of wood, with a safety-string attached, which is placed between the molar teeth. The mouth-piece is next placed over the mouth, the nostrils are closed with the thumb and fingers, the gas is turned on, and the patient is instructed to take deep breaths. Soon after the gas is inhaled slight cyanosis of the face appears, and usually in one minute it loses its expression and is deeply cyanosed, the pupils dilate, the breathing becomes stertorous, the conjunctiva insensitive, and the respiration slow and shallow. Complete anæsthesia is indicated by cyanosis and stertor. As soon as the inhalation of the gas is stopped the cyanosis disappears, the stertor ceases, and consciousness returns.

The shortness of the period of anæsthesia induced by nitrous oxide gas unfortunately prevents its employment in the majority of surgical operations. An abscess may be opened, or teeth extracted, but any operation occupying more than a few minutes cannot be undertaken under this variety

of anæsthesia. It is, as before stated, the safest and most prompt in its action of the anæsthetics known at the present time.

Preparation of Patient for General Anæsthesia by Ether or Chloroform.—The patient should take no solid food for at least five or six hours before the anæsthetic is given; when it is possible, the bowels should be previously opened, and the urine should be voided just before the administration of the anæsthetic, as it is apt to be passed during the anæsthesia, and may infect the wound or soil the clothing.

In feeble patients the administration of an ounce of whiskey half an hour before the anæsthetic is given is a useful precaution. False teeth or foreign bodies, such as tobacco, chewing-gum, etc., should be removed from the mouth. The patient should be placed in the recumbent posture, syncope being less apt to occur in this position, as it facilitates the circulation between the heart and the brain, and the head should be turned to one side. Care should always be taken that there is no tight clothing around the neck, chest, or abdomen which might embarrass the respiratory action. The lips, nose, and anterior nares should be anointed with cosmoline, to save them from irritation by the anæsthetic; this is especially important if chloroform is employed; the eyes should also be covered with a towel, to prevent irritation of the conjunctiva. The urine should be previously examined, if possible, especially if ether is to be administered.

The anæsthetizer should always listen to the heart's action as a part of the routine preparation before giving an anæsthetic: this enables him to detect any irregularity in its action, and at the same time has a good moral effect upon the patient, especially if he can assure him that he can take the anæsthetic with safety. The anæsthetizer should attend to the administration of the anæsthetic only, and should watch carefully the condition of the pulse, respiration, and pupils.

In administering an anæsthetic to females, a second person should always be present, as these drugs often cause erotic sensations, and the patient after recovering from their effect may have the impression that she has been subjected to undue liberties, which impression can best be refuted by the statement of a witness who was present at the time. It is always well to have another physician present during the administration of a general anæsthetic, as unforeseen difficulties occasionally arise.

There should always be at hand tongue forceps, and instruments with which tracheotomy may be performed if necessary, also whiskey, nitrite of amyl, digitalis, and strychnine, and a hypodermic syringe.

ETHER.

Ether is at the present time the substance which is most widely employed in North America for the induction of general anæsthesia; if carefully and intelligently administered, its use is attended with comparative safety, and there are few conditions which contra-indicate its employment. The accidents which we have seen occur during its use have been largely the results of carelessness on the part of the anæsthetizer, and have generally been due to mechanical asphyxia from the accumulation of mucus or vomited matters in the pharynx, or from falling back of the tongue, or from

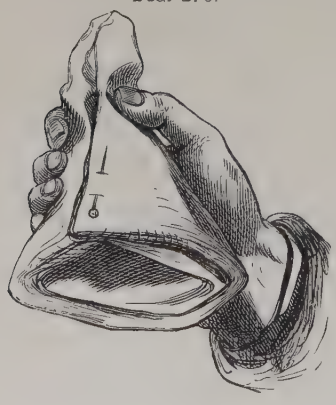
crowding a wet and softened ether cone over the nose and mouth, suffocating the patient; the latter condition might be produced by a similar use of a towel which contained no anæsthetic substance.

The use of ether is attended with risk, in cases of advanced organic disease of the kidneys, of causing suppression of urine. Its use also in cases of extensive atheroma of the arteries is attended with danger, because of the vascular excitement in the primary stage of its administration, which may cause rupture of an artery from increased tension. In cases of emphysema, chronic bronchitis, empyema, dyspnœa, or abdominal distention, the use of ether is attended with considerable risk. The extremely inflammable character of the vapor of ether should be borne in mind in using the actual cautery and in bringing lights near a patient when operating at night; it should be remembered that the vapor of ether is heavier than the air and falls, so that lights may be brought near the wound with safety if they are held above the level of the ether inhaler.

Ether may be administered by the open or by the closed method; in the former there is allowed free access of air, and in the latter the patient breathes out of and into a bag containing vapor of ether, getting a more or less imperfect supply of air. By the latter method asphyxiation is more likely to occur, so that the open method of administration is the safer and the one generally employed in this country.

Administration of Ether.—Ether may be administered by means of a towel folded into the shape of a cone. (Fig. 176.) A few layers of stiff paper interposed between the outer layers of the towel will keep the cone in

Fig. 176.



Ether cone.

Fig. 177.

Allis's inhaler.

shape and will prevent the evaporation of ether from its external surface. Ether may be administered by one of the ordinary inhalers, and of these we have found Allis's inhaler (Fig. 177) the most satisfactory. It consists of a metallic framework covered with hard rubber or metal, which contains a number of folds of a roller bandage, presenting a large surface for the rapid evaporation of the drug. The patient being prepared as previously described, and the head being turned to one side, half an ounce of ether is poured into the cone or inhaler, and it is placed over the nose and mouth

of the patient. He is then requested to take deep breaths, or to blow the ether away, which latter procedure causes him to take deep inspirations. In the beginning of etherization the patient will resist the inhalation much less if the ether is given slowly, with a plentiful admixture of air. The first effect of the inhalation of ether is the production of acceleration of the pulse and respiration; the mucous membrane of the air-passages is irritated, and coughing often occurs, and the patient complains of a sense of suffocation. To avoid these symptoms the nasal mucous membrane may be sprayed with a two or four per cent. solution of *cocaine* just before the administration of the anæsthetic, and this spraying should be repeated every half-hour while the anæsthetic is used. By the use of cocaine in this manner the nasal reflexes are diminished, the stage of excitement is shortened, the sense of suffocation is diminished, and vomiting is less likely to occur. In the early stage of etherization there is a disposition to muscular movements, so that frequently it becomes necessary to restrain the patient; the brain is also excited, and the patient is apt to talk or cry out. These symptoms call for a continuance of the administration of the ether, and not for its withdrawal. Succeeding this stage, if the ether be pushed, profound anæsthesia takes place, as is evidenced by the loss of consciousness, relaxation of the muscular system, moist skin, loss of special senses, contracted pupils, and slow and deep respiration, tending to become stertorous. When the conjunctiva is insensitive to the touch of the finger the anæsthesia is usually profound.

First Insensibility from Ether.—There exists early in the course of the administration of ether a stage of primary anæsthesia, which lasts for a minute or more, and which may be taken advantage of to perform such a minor surgical operation as the opening of an abscess, the reduction of a dislocation, or the extraction of a tooth. The recovery from this condition is usually very prompt, and is not followed by nausea and the after-effects which attend the prolonged administration of ether.

When the anæsthesia is profound the amount of ether inhaled should be diminished, and the patient given only so much as will keep him well under its influence. It is surprising how small a quantity of ether a careful and watchful anæsthetizer will require to keep the patient fully under its effects for a very considerable time. The time required to produce complete anæsthesia by ether varies in different cases: anæsthesia is produced in children in a few minutes; in adults from ten to fifteen minutes are usually required; drunkards require a large amount of ether and take a long time to come under its influence.

When the administration of the drug is stopped, the patient may continue for some time in an unconscious condition, resembling a quiet sleep, or he may awake and exhibit more or less symptoms of cerebral excitement.

Accidents during Etherization.—During the administration of ether, particularly in the early stage, the patient may suddenly stop breathing, the face at the same time becoming cyanosed. This condition calls for the withdrawal of the ether, and if an inspiratory effort does not quickly follow, pressure should be made upon the front of the chest, and when this is relaxed a deep inspiration usually takes place and no further

difficulty is experienced. This condition should not be confounded with the very common effort to hold the breath, the latter occurring with the chest fully expanded, the former with the chest empty.

Vomiting may occur during etherization, and the vomited matter may accumulate in the pharynx or the mouth and obstruct the breathing, or may enter the larynx or the trachea and cause a like result. Vomiting is more apt to take place if solid food has been taken shortly before the administration of the anæsthetic. If this accident occurs and interferes with the breathing, the jaws should be opened and the head turned to one side, when the vomited matter will usually escape without difficulty. If, however, food has entered the larynx, and is not ejected by coughing, it will be necessary to open the trachea and hold the tracheal wound open, or to introduce a tube and practise artificial respiration. The breathing may also be obstructed by the accumulation of *mucus* in the pharynx, which is less likely to occur if the head is kept on one side during the administration of the drug; if it occurs, the head should be turned to one side, the jaws opened, and the mucus removed by small sponges securely fixed to sponge-holders. When muscular relaxation is complete during anæsthesia, the *tongue* may fall backward and obstruct the breathing; this accident also is less likely to occur if the head is kept on one side during the etherization. If *asphyxia* results from this accident, the tongue may be brought forward by placing the fingers on each side beneath the angles of the inferior maxillary bone and pushing the jaw forward, at the same time over-extending the neck by bending the head backward (Fig. 178), or the mouth should be opened and the tongue drawn forward by tongue forceps. Either of these manipulations is usually sufficient to re-establish the respiratory movements. If, however, in any of these forms of mechanical asphyxia respiratory action is not promptly restored, some form of *artificial respiration* should be resorted to, either Laborde's, the direct, Silvester's, or forced respiration; and of these Laborde's method, by rhythmical traction of the tongue, and forced respiration, have yielded the most satisfactory results. *Failure of respiration* may also occur from paralysis of the respiratory centres or spasm of the respiratory muscles; the former may occur from an overdose of the anæsthetic or from intercurrent asphyxia, syncope, or morbid states of the respiratory system.

Fig. 178.

Pushing the jaw forward.

Spasmodic respiratory failure may occur before complete anæsthesia, and it is liable to arise in muscular and emphysematous subjects. Respiratory failure from either of these causes should be promptly treated by artificial respiration and the hypodermic use of strychnine, atropine, or digitalis.

After-Effects of Ether.—After complete anæsthesia from ether, nausea and vomiting are very common: they may last for only a short time or may persist for hours. If persistent, the swallowing of a few mouthfuls

of hot water will often relieve the condition, or the administration of cocaine hydrochlorate, gr. ¼, with crushed ice, repeated two or three times, or the use of crushed ice with champagne or brandy, may be followed by satisfactory results.

The administration of ether vapor by the *rectum* was employed a few years ago; but, although anæsthesia was quickly produced, dangerous symptoms often followed its use, as its absorption after the vapor had once been introduced into the rectum could not be controlled, so that this method of administration has been abandoned.

CHLOROFORM.

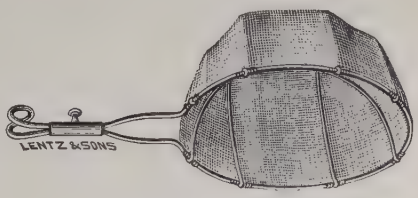
Chloroform has been shown to be a more dangerous anæsthetic than ether, and, although it is widely employed in Great Britain and upon the Continent, it is not generally used in this country except in certain districts, the South and Southwest, and here its use is followed by fewer fatalities than in Northern climates, so that it has been suggested that it is safer in warm climates. In Germany it is rapidly being superseded by ether.

A patient should be prepared for the administration of chloroform in the same way as for the use of ether, similar precautions being taken as regards the removal of false teeth and foreign bodies from the mouth and of tight clothing from the neck or chest.

Clinical experience has demonstrated the fact that chloroform can be used in children and aged subjects and in puerperal cases with comparative safety. It is also to be preferred to ether in patients suffering with advanced renal disease, emphysema of the lungs, and chronic bronchitis. It is preferred to ether by some surgeons in operations about the mouth where the actual cautery is employed, on account of its less inflammable character.

Administration of Chloroform.—Chloroform may be administered by pouring from half a drachm to a drachm upon a folded towel, which should be held at first a few inches from the mouth and nose, and then gradually brought nearer, but should not be allowed to come in contact with the skin, as its irritating action will blister the surface. In administering chloroform the anæsthetizer should remember that one of the dangers in its use is the too great concentration of its vapor, and should therefore be careful to see that a sufficient admixture of atmospheric air takes place.

Fig. 179.



Esmarch's chloroform inhaler.

Chloroform may also be administered with Esmarch's inhaler (Fig. 179), which consists of a wire frame covered with gauze, or by the use of Clover's inhaler; the object of the latter inhaler being to regulate the amount of chloroform inhaled and to secure a proper admixture of atmospheric air.

During the administration of chloroform the anæsthetizer should watch carefully the character of the respiration, the pulse, and the pupils, and should not for a moment have his attention diverted from the patient.

Profound chloroform anæsthesia is manifested by insensibility of the conjunctiva to the touch, absence of the reflexes, complete muscular relaxation, and, usually, contracted pupils. When this stage is reached the inhalation should be stopped, and after this time only so much chloroform should be administered as is sufficient to keep the patient fully under its influence.

Complete anæsthesia should be produced before any operation is begun: if undertaken before that time, syncope may be produced by reflex inhibition of the heart. If convulsive movements take place before the patient is fully anæsthetized, and the face becomes cyanosed, the inhalation should be discontinued until these symptoms disappear. The pupils should also be carefully watched, to see if they respond to light or if they are contracted. If the anæsthesia is not complete, insensibility to light or wide dilatation is a sign of danger which calls for the removal of the anæsthetic and active treatment to stimulate the circulation and respiration. If the inhalation of chloroform has been stopped and is again in a short time resorted to, it should be given very carefully and slowly, for syncope may suddenly develop from the fact that the heart or the respiration may feel the effect of the previous use of the drug.

Accidents during Chloroform Anæsthesia.—*Mechanical asphyxia* may occur during anæsthesia produced by chloroform, as well as that by ether, by the obstruction of the respiratory passages by blood, mucus, foreign bodies, or the tongue falling backward over the epiglottis. These accidents should be treated in the same manner as similar accidents occurring during etherization. Considerable diversity of opinion exists among different observers as to whether death resulting from chloroform is due to failure of the heart or failure of the respiration, and each has brought forward a large amount of evidence to prove his views correct. Although it has been demonstrated that chloroform is a direct depressant and paralyzant to the heart-muscle or its contained ganglia, yet clinical experience shows that paralysis of the respiratory centres is probably the most important factor in causing death during chloroform anæsthesia, for circulatory failure in these cases is due to embarrassed or suspended breathing, and the only method of treatment which has been found of value is that which tends to bring about respiratory action—namely, some one of the various forms of artificial respiration. Death from the administration of chloroform results from cardiac failure or from respiratory arrest, and the dangerous symptoms develop so rapidly that the greatest promptness is required to meet them.

Syncope developing during the administration of chloroform, manifested by pallor, fluttering or arrested pulse, and cessation of respiration, should be treated by lowering the patient's head, the use of a rapidly interrupted electric current, the hypodermic injection of digitalis, atropine, or strychnine, and the employment of artificial respiration, either the direct method or Laborde's method, and, as in cases of threatened death from ether, the treatment should not be desisted from for some time, as by persistent employment of these means apparently hopeless cases have been resuscitated.

Ethyl Bromide.—Ethyl bromide is a colorless, volatile liquid which has been employed quite largely as an anæsthetic. Ethyl bromide produces a loss of sensibility before consciousness is completely lost, and does not produce complete relaxation of the muscles, which interferes much with its usefulness as an anæsthetic in surgical operations. Its prompt action and the brevity of the narcosis would recommend it in many cases, but the fact that its use is not devoid of danger—for a number of deaths have followed its employment as an anæsthetic—will, we think, prevent its general use as an anæsthetic. If ethyl bromide is employed, care should be taken that it is not confused with ethylene bromide, which is a much more dangerous substance. The mode of administration of ethyl bromide is similar to that of ether.

MIXED ANÆSTHESIA.

This method consists in inducing anæsthesia with one substance and continuing its effect with another, or in producing anæsthesia by a mixture of several anæsthetics. In England a popular method consists in giving nitrous oxide gas until anæsthesia is produced, and then keeping up its effect by the administration of ether. This method we have seen employed most satisfactorily; it is probably one of the safest means of producing anæsthesia, and has also the promptness of its action to recommend it. Oxygen has also been used with ether, the gas passing from a cylinder through a wash-bottle containing ether, and thus driving the latter with it through an inhaler similar to that used in the administration of nitrous oxide gas. This combination has been highly recommended by some surgeons, but is expensive, and is not likely to be generally employed.

A. C. E. Mixture.—Various mixtures of chloroform, ether, and alcohol have been used to produce anæsthesia, but that which has been most widely employed is known as the A. C. E. mixture, consisting of chloroform, 3 parts; ether, 1 part; alcohol, 1 part. Some surgeons employ this mixture with the idea that the dangers of chloroform are diminished by its combination with ether and alcohol, but clinical experience has not proved this view to be correct. It should therefore be used with the same care as chloroform. It should be administered upon a towel, or with an inhaler, in the same manner as chloroform, and the patient should be watched as carefully during its inhalation as during the administration of the latter drug, and accidents occurring during its use should be treated in the same manner as those arising during the administration of chloroform. Those who have had a large experience with this anæsthetic recommend its use in the case of children and in stout, flabby subjects suffering from shortness of breath, in patients suffering from advanced disease of the heart or blood-vessels, and in operations upon the neck, mouth, and pleura.

After-Effects of Anæsthesia.—Nausea is not common after chloroform anæsthesia. The treatment of this condition following etherization has been previously described. The temperature is usually notably lowered by anæsthetics, so that it is always well to apply artificial heat and keep the patient well covered. A form of mental disturbance known as *confusional insanity* is often attributed to the use of anæsthetics, but, as it does not usually

develop until some time, often two or three weeks, after their employment, H. C. Wood is of the opinion that the relation between the mental symptoms and the anæsthesia has not been clearly proved in these cases, and that it is rather the outcome of a peculiar depression of the cerebral cortex produced by the shock of the operation itself, or by the emotional strain due to the surgical illness. This view seems to be confirmed by the fact that many of the cases of emotional insanity which are observed follow injuries in which no anæsthetic has been given. Albuminuria and glycosuria may follow the administration of ether or chloroform, but are usually only temporary conditions.

CHAPTER XIII.

AMPUTATION.

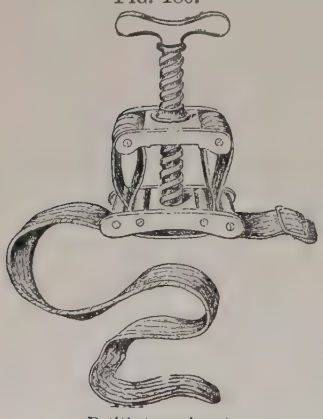
THE term amputation at the present time is generally restricted to the operation for the removal of a part or the whole of a limb. A limb may be amputated through its bones or through its joints; the former operation is known as an amputation in the *continuity* of the limb, the latter as an operation in the *contiguity*, or as a *disarticulation*. Amputation is now much less frequently resorted to than formerly, since the general introduction of asepsis in the treatment of wounds, and also from the fact that in many injuries involving joints the more conservative operation of excision is practised with success. In the lower extremity amputation is more frequently required than in the upper extremity; in the latter the very free collateral circulation and the limited disability which follows shortening render excision and resection often more advisable than amputation.

Conditions requiring Amputation.—**Compound Fractures and Dislocations.**—These injuries are common accidents and often demand amputation. Extensive comminution and loss of bone, especially in the lower extremity, is an indication for amputation. **Avulsion of a Limb.**—When a limb is torn or crushed off by machinery, by the wheels of wagons or railroad-cars, although the part may have been removed or may be only hanging by a few shreds of skin, muscle, or tendon, amputation is indicated to promote the healing of the wound and insure the formation of a well-shaped stump. **Gangrene.**—Gangrene involving the extremities, when more than a localized superficial sloughing is present, is usually a cause for amputation. For the indications for amputation in the special varieties of gangrene the reader is referred to the article upon this subject. **Effects of Cold and Heat.**—Amputation may be required for the conditions arising from exposure to cold or the destruction of a portion of the limb arising from scalds or burns. **Lacerated and Contused Wounds.**—The damage to the skin, muscles, blood-vessels, and nerves produced by railway or machinery accidents, or by the bites of animals, although the bones have escaped injury, may demand amputation. **Gunshot Injuries.**—The damage done to the bones, joints, blood-vessels, and nerves in gunshot injuries may demand amputation, although in modern warfare the change in the missiles which are employed and the introduction of asepsis in wound treatment have done much to render this operation less necessary than formerly. In these cases, as well as in civil practice, the operation of excision is now frequently employed in the place of amputation. **Inflammatory Affections of Bones and Joints.**—Although amputations are less frequently required in these cases than formerly, owing to the substitution of excision or arth-

rectomy and the improved treatment of the early stages of these diseases, there are still cases in which, from the extent of the bone involved and the implication of the soft tissues, amputation is the safer procedure. **Injuries of Blood-Vessels.**—Amputation is sometimes required for injuries of the larger arteries and veins, as well as for aneurisms which have become diffused. **Malignant Growths.**—These growths, when involving the bones of the extremities, or when extensive and situated in the soft parts and closely attached to important blood-vessels and nerves, so that their removal is dangerous or impossible, often demand amputation. **Deformities.**—Amputation may be required for the relief of deformities, either natural or acquired; but since the introduction of osteotomy many deformities of the bones which were formerly subjected to amputation can be satisfactorily corrected by this procedure. Occasionally, after injuries and fractures, a limb will present so much deformity that the patient will be in much better condition if the part be removed by amputation.

Instruments required for Amputation.—The instruments required for amputation are a tourniquet or other means of controlling the circulation during the operation, knives of various shapes and sizes, a saw, bone forceps, artery or hæmostatic forceps, retractors, scissors, ligatures, sutures, and suture needles.

FIG. 180.



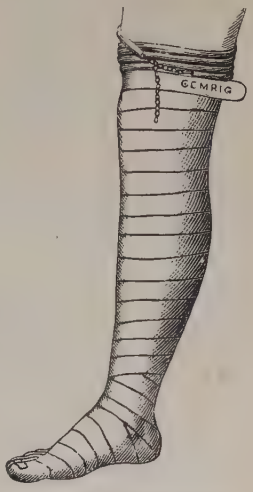
Petit's tourniquet.

Tourniquets.—The control of the bleeding during amputation is a very important part of the procedure. This may be accomplished by the use of the ordinary tourniquet, known as Petit's tourniquet (Fig. 180), which consists of two metal plates, the distance between which is regulated by a screw, with a strong linen or silk strap provided with a buckle. In applying this, a few turns of a bandage are passed around the limb, and a firm pad or compress is secured immediately over the main artery; upon this pad is placed the lower plate of the tourniquet, so that the artery is held between this plate and the bone; the strap is then buckled tightly enough to keep the instrument in place. The compress is next forced down upon the artery by turning the screw and separating the plates, until the circulation is completely arrested through the vessel. Other forms of tourniquets, such as the horseshoe tourniquet, or Skey's abdominal tourniquet, are sometimes employed.

Esmarch's Hæmostatic Apparatus.—The hæmostatic apparatus now generally employed is known as Esmarch's bandage, and consists of a rubber bandage and an elastic tube or strap. The bandage is applied to the parts from the lowest extremity of the limb to a point some distance above the seat of the proposed amputation. (Fig. 181.) The elastic tube or strap is then firmly wound about the limb at the upper end of the bandage, and the rubber bandage is removed. This renders the limb bloodless, preventing the loss of blood during the operation, and adds

to the bulk of the circulation the amount of blood which was in the limb before it was rendered anæmic. Esmarch's bandage is now very generally used, and has proved a most valuable means of controlling hemorrhage and of saving blood during the operation, but caution should be observed in its use. The elastic constricting band should be applied for as short a time as possible and only firmly enough to control the circulation, for damage to the blood-vessels and nerves may occur from its too prolonged and tight application. The principal disadvantage in the use of elastic constriction consists in the fact that very troublesome oozing or consecutive hemorrhage follows by reason of a vaso-motor paralysis, which results from the pressure of the strap. This may be in a measure prevented by quick removal of the elastic constricting band as soon as the larger vessels have been secured. In operating upon the hands and feet of children an ordinary rubber drainage-tube may be employed instead of the elastic strap, to control the bleeding. In emergencies, where an ordinary elastic tube cannot be obtained, a pair of elastic suspenders may be employed in place of the elastic strap of Esmarch.

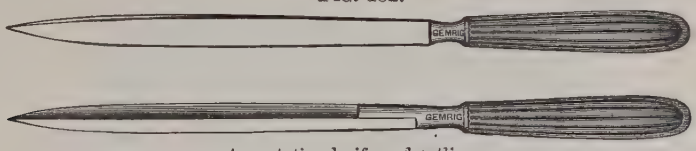
Fig. 181.



Esmarch's bandage applied.

Amputating Knives.—Formerly, when transfixion was the favorite method of amputation, very long amputating knives were used, but at the present time a stout scalpel having a blade three inches in length, or an amputating knife with a blade from six to eight inches in length, is usually employed. (Fig. 182.) A double-edged knife, known as a

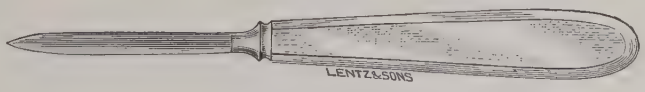
Fig. 182.



Amputating knife and catlin.

catlin (Fig. 182), is sometimes employed for dividing the interosseous tissues in operations where there are parallel bones. In amputations through the tarsus or of the metacarpal bones, or of the fingers or toes, a short, narrow-

Fig. 183.



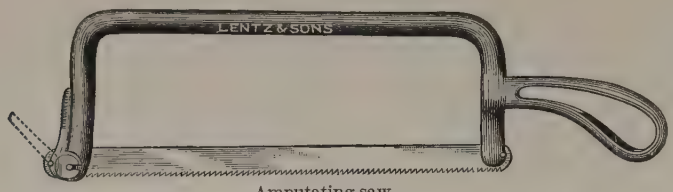
Neill's finger knife.

bladed bistoury, known as Neill's finger knife, will be found a most useful instrument. (Fig. 183.)

Saw.—An amputating saw should have a blade about ten inches in length and two or two and a half inches in width, or a bow-saw with a narrow blade (Fig. 184) which is reversible and can also be used for excisions

is frequently employed. For amputations about the hands and feet a narrow-bladed metacarpal saw will often be found useful.

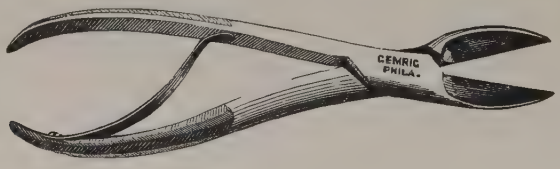
Fig. 184.



Amputating saw.

Bone Forceps.—Bone forceps may be used for dividing the phalanges in amputations, or for smoothing off any rough edges of the bone which have been left by the saw. (Fig. 185.)

Fig. 185.



Bone forceps.

Periosteotome.—A periosteotome is sometimes employed before the bone has been divided, to loosen and turn up a cuff of periosteum, which, after the bone has been divided, is drawn down and secured over the sawn surface of the bone. (Fig. 186.)

Fig. 186.

Periosteotome.

Artery or Hæmostatic Forceps.—Artery or hæmostatic forceps are also required. These instruments should be self-retaining, so that if the bleeding is profuse from small vessels after the tourniquet is removed, a number of vessels may be clamped rapidly and the forceps allowed to remain in place, and, finally, when all bleeding has been arrested, the arteries can be twisted or ligatured before the forceps are removed.

Retractors.—These consist of pieces of muslin from six to eight inches in width and twenty-four inches in length, one end of which is split into two or three tails. The former variety of retractor is employed where one bone is divided, as in amputations of the arm and thigh ; the latter in cases where two bones are divided, as in amputations of the forearm and leg.

Ligatures.—Sterilized catgut or silk ligatures are usually employed to secure the vessels after amputation.

Sutures and Needles.—A great many different materials are employed for sutures in bringing together the flaps in amputations. Silk-

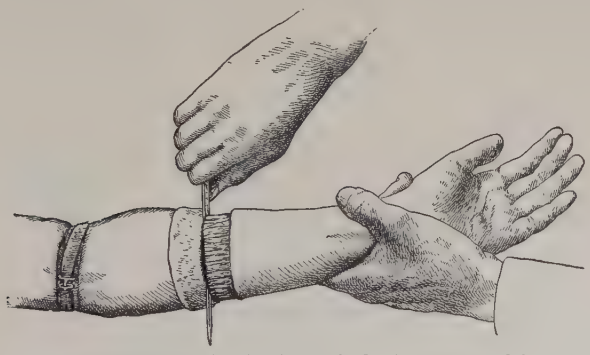
worm-gut, catgut, silk, and silver wire may be employed, the principal requirement being that the material shall be one which can be easily sterilized, and is sufficiently strong to hold the flaps together until union has occurred. Personally we prefer catgut for buried sutures, and either silk or silkworm-gut for approximation of the flaps. The *needles* employed in closing the stump may be either curved or straight, according to the choice of the surgeon.

METHODS OF AMPUTATING.

Amputations may be performed by the circular, flap, oval or modified circular, and elliptical methods, or Teale's method by rectangular flaps. In forming flaps in amputation the operator should allow for the contraction of the skin and retraction of the muscles: the old rule was to allow one finger-breadth for contraction of the skin and two for retraction of the muscles.

Circular Method.—In performing an amputation by this method the incision of the skin is made at some distance below the point where the bone is to be divided. An assistant grasps the limb and draws the skin evenly and firmly towards the root of the part, and the surgeon passes the heel of the knife well into the tissues and makes a circular sweep around the limb, completing the division of the skin and cellular tissue with one motion of the knife. The second incision in amputation by the circular method consists, after retraction of the skin, in making a circular cut through all the tissues down to the bone. (Fig. 187.) The third step in this form of

FIG. 187.



Amputation by the circular method. (After Esmarch.)

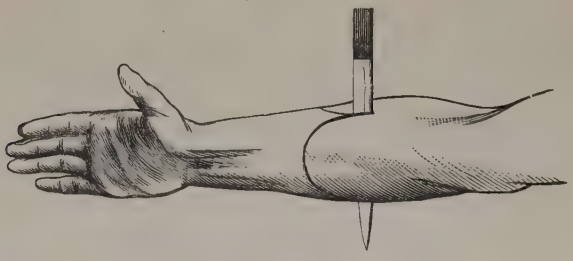
amputation consists, after retracting the skin and muscles and holding them back by retractors, in the division of the bone with a saw. In some cases a cutaneous sleeve, consisting of the skin and cellular tissue, is dissected up and turned back, and sometimes it may be necessary to make a slit in one side of the flap to allow this to be done. The subsequent steps in the operation are similar to those which have just been described.

Flap Method.—This method of amputation is susceptible of many variations: there may be one or two flaps of equal or unequal length; the flaps may be cut antero-posteriorly, laterally, or obliquely; they may also be made by transfixing the limb and cutting outward, or may be cut from without inward, or may be formed so as to include the whole thickness of

the tissues down to the bone, or merely the skin and superficial fascia, the deep structures being divided by a circular incision. The flaps may have a curved outline, or may be rectangular in shape.

Transfixion Method.—In amputation by transfixion (Fig. 188) the surgeon grasps the limb and enters the point of a long knife into the tissues

Fig. 188.

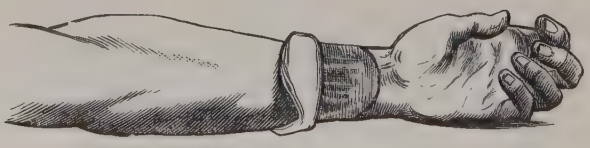


Forming flaps by transfixion. (Agnew.)

at the side nearest himself, pushing it across and around the bones, bringing it out through the skin diametrically opposite its point of entrance. He then shapes the flap by cutting downward with a rapid sawing motion until a flap of sufficient length has been formed, and next cuts obliquely outward until all the tissues are divided. The flap being turned up and held out of the way, he re-enters his knife at the same point at the opposite side of the bone or bones, and cuts a second flap of equal length in the same manner.

Modified Circular or Oval Method.—In this form of amputation two oval skin-flaps, antero-posterior or lateral, are turned up (Fig. 189), and the muscles are next divided down to the bone by a circular sweep of the knife.

Fig. 189.



Amputation by oval flaps. (Agnew.)

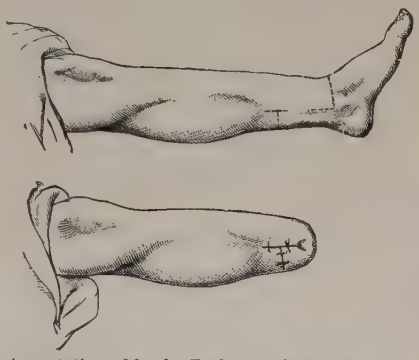
This form of amputation is at the present time very widely employed, and is especially to be recommended in cases of amputations in muscular limbs.

Elliptical Method.—This is a form of the oval method of amputation which is employed in amputations at the knee- and elbow-joints. The incision in this form of amputation forms a perfect ellipse, coming below the joint on the front or outside of the limb, the resulting flap, folded upon itself, making a curved cicatrix and furnishing an excellent covering for the stump.

Teale's Method by Rectangular Flaps.—In this method of amputation two flaps are made of unequal length, and the incisions are so planned that the shorter flap contains the more important vessel or vessels. The flaps are cut of equal widths; the length of the long flap should be one-half the circumference of the limb at the point where the bone is to be divided, and that of the short flap should be one-eighth of the circum-

ference of the limb. The flaps are cut from without inward, and embrace all the tissues of the limb down to the bone. After the flaps have been dissected up, the bone is divided with a saw, and after the bleeding has been arrested the long flap is folded over and sutured to the short flap. (Fig. 190.) The disadvantages of this method of amputation are that in muscular limbs it requires the bone to be divided at a higher point than would otherwise be necessary, and there is also liability to sloughing of the long flap.

Fig. 190.



Amputation of leg by Teale's method. (Bryant.)

Periosteal Flaps.—In any of the methods of amputation previously described the periosteum may be dissected up in two flaps attached to the muscles, or pushed up as a sleeve by means of a director or periosteotome before the bone is sawed. This procedure is most easily accomplished in young subjects. When periosteal flaps have been made before closing the wound, they should be brought down over the end of the bone and their edges approximated by a continuous catgut suture. In this way the periosteum covers the cut surface of the bone, to which it soon forms adhesions.

Relative Value of the Different Methods.—It is well for the surgeon to have in mind the different methods of amputation, for he should not confine himself to any one method, but should practise the procedure which seems to him best adapted for the special case. In many cases the laceration of the tissues or other conditions may prevent the performance of any formal operation, and in such cases the surgeon may have to cut his flaps and modify the operation according to the conditions presented. In amputations just above the ankle or in the forearm, the circular method is quite satisfactory. In the leg, some form of the flap or the modified circular method can be practised with the best results; while in the arm and thigh the modified circular method is the one generally employed. At the knee or elbow the oval or the elliptical method is usually practised. The operations for particular parts of the extremities will be considered in discussing Special Amputations.

Period of Amputation.—Amputations may be done in the primary, the intermediary, or the secondary period. The *primary* period is the time before traumatic fever has developed. In cases of injury the surgeon should, if possible, amputate during this period, but he will often have to delay the operation for some hours, if the patient is suffering from shock, until reaction has occurred. The *intermediary* period is that after traumatic or septic fever has developed: this is not considered a favorable period in which to undertake amputation. The *secondary* period is that after suppuration or septic inflammation has developed and has gradually subsided. This is a comparatively favorable period for amputation. These various periods are not now so clearly defined as formerly, since the introduction

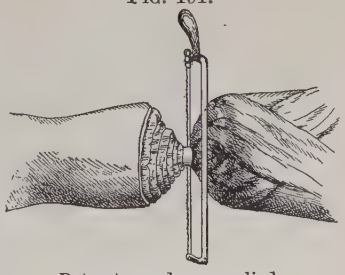
of antiseptic methods; the primary period is often much prolonged, and the intermediary and secondary sometimes do not exist. Extensive experience has shown that the primary period is the most favorable for amputation.

Preparation of the Patient for Amputation.—Many patients suffering from injuries which demand amputation are not in condition to bear the operation when they come under the care of the surgeon. Such patients are usually suffering markedly from shock, and the first indication in their treatment is to bring about reaction. This is accomplished by the use of external heat, diffusible stimulants, and the use of strychnine hypodermically, and in some cases by the intravenous injection or the infusion of saline solution. While the treatment of shock is being carried out, the injured part should be exposed, to see that the patient is not losing blood. If there is no active bleeding from the wound, it should be carefully irrigated with a solution of bichloride, and the surrounding skin gently rubbed over with turpentine, which should be followed by the use of soap and water, and finally thoroughly irrigated with a 1 to 2000 bichloride solution, and the part should be wrapped in several towels wrung out of bichloride solution. If it is found that there is a moderate amount of bleeding, and the bleeding vessels can be seen by carefully exploring the wound, they should be secured by ligatures. If the bleeding arises from a number of small vessels and constitutes a continuous oozing, the wound should be firmly packed with strips of bichloride or sterilized gauze, and a compress of gauze should be placed over the wound and held in position by a firmly applied bandage. If, however, the bleeding is free, the application of a tourniquet may be necessary. The elastic tube of the Esmarch apparatus is the appliance which will usually control the bleeding most promptly and perfectly. We think that in many cases the elastic tube or strap is used improperly, from the fact that it is often applied high up upon the limb away from the wound, is applied too tightly, and is allowed to remain for too long a time. A tightly applied Esmarch elastic strap soon becomes very painful to the patient, and for this reason we prefer not to use it where the bleeding can be controlled by simple packing of the wound and the use of a compress and a bandage. If the Esmarch strap is required to control hemorrhage, we apply the strap over the wound, or as near the wound as possible, preferring to apply it to the contused and lacerated tissues of the wound itself, which are not to be included in the flaps when the amputation is done, for we are certain that sloughing, which sometimes occurs in the flaps after amputation, is often due to the injury done to the tissues by the prolonged use of elastic constriction. We have seen an Esmarch tube unwisely applied over the femoral artery in the thigh in the case of a crushed foot and allowed to remain for some hours, the parts in the region of the operation being for this time rendered bloodless and cold. We urgently recommend that where the Esmarch tube is used to control hemorrhage previous to amputation or during the period of reaction it be applied as nearly as possible over the wound. When reaction has been established, as is evidenced by the improvement in the pulse and the rise of temperature to or a little above the normal, the patient may be considered in condition for the operation.

Amputations during Shock.—The question of amputating while the patient is suffering from shock is one which has received a great deal of attention, and at the present time the weight of surgical opinion is decidedly against the operative procedure in this condition. There are, however, cases in which the condition of shock is probably kept up by the presence of the lacerated tissues, and in which, in spite of treatment, reaction is not established. In such cases it seems scarcely humane to allow the patient to die without attempting operative treatment. In these cases we often administer an anæsthetic, and if the patient's condition improves under its use we continue it until anæsthesia is produced, and then rapidly perform the amputation; and, although many cases subsequently die of shock, recovery follows in a sufficient number of cases to justify the procedure.

Details of an Amputation.—The parts having been previously thoroughly sterilized, the patient is anæsthetized and is moved to the operating-table, or, if the operation is to be done upon his bed, the bed is prepared by placing under the limb a rubber sheet and over this a sheet which has been wrung out of bichloride solution. The instruments, having been sterilized, are placed where they can be within easy reach of the surgeon. The surgeon should first consider the means of controlling the bleeding during the operation. If the patient has lost a considerable quantity of blood it is important that as much blood as possible be saved, and, with this end in view, an elastic bandage should be applied from the lowest portion of the limb to the point at which the constricting band or tourniquet is to be applied. We prefer to use for the control of hemorrhage during the operation an elastic strap, which is wrapped several times around the limb at a point where the large nerves are not close to the surface. This having been secured, we next apply an ordinary Petit's tourniquet a short distance above it, so that when the constricting band is removed this can be screwed down and control any bleeding which is present. Having controlled the circulation of the part, an assistant should hold the limb firmly some distance above the seat of operation, and a second assistant should hold the limb below the seat of operation. The surgeon then decides upon the method of amputation he desires to employ, and makes his incisions accordingly. After the flaps have been cut and the soft parts over the bones have been divided, a retractor is applied to hold the soft parts back, while the bone or bones are divided with a saw. (Fig. 191.) After the limb has been removed, the surgeon first seizes the main artery or arteries with hæmostatic forceps and then searches for the smaller vessels, and when as many as possible have been seized with forceps, they are tied off in turn with ligatures and the forceps are removed. After securing the principal vessels the elastic tube should be removed, and if any arteries spurt after its removal they should be grasped with hæmostatic forceps and ligatured. If free bleeding occurs from a number of points,

Fig. 191.



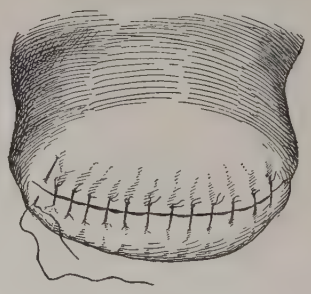
Retractor and saw applied.
(After Esmarch.)

the Petit's tourniquet, which has been secured around the limb above, should be screwed down so as to control the hemorrhage. After all vessels have been secured, any nerves which are exposed in the wound should be drawn out for a short distance and resected, and tendons which project in the stump should also be retrenched. The flaps and the surface of the stump may now be irrigated with hot bichloride solution or with hot sterilized water; the latter application is especially useful if there is considerable oozing from the muscles. If the surgeon does not wish to use antiseptic solutions he may simply sponge or mop off the surface of the flaps with pads of sterilized gauze, and the question of drainage should next receive attention. If one is sure of his asepsis during operation and the bleeding has been absolutely controlled, it is possible in many cases to close the stump without drainage, and this procedure is recommended by many surgeons. We are of the opinion, however, that the introduction of a drainage-tube is useful, for if consecutive bleeding occurs after reaction the blood escapes from the stump, and does not stuff the stump and cause tension upon the flaps. We therefore consider it wiser before closing the flaps to introduce a short rubber drainage-tube at the most dependent portion of the wound. Where it is possible, the deeper parts of the wound are brought together by continuous or interrupted sutures of catgut (Fig. 192); a second layer of sutures is then introduced to approximate the edges of the flaps. (Fig. 193.) The suturing material for

Fig. 192.

Application of deep sutures. (After Esmarch.)

Fig. 193.



Approximation of edges of flaps. (After Esmarch.)

this purpose may be catgut, silk, or silkworm-gut. The stump having been closed, the cavity may or may not be irrigated through the drainage-tubes, according to the judgment of the surgeon, with sterilized water or with bichloride solution. The surface of the stump should then be irrigated and cleansed, and next a narrow strip of protective may be placed over the line of sutures, or this may be omitted and the line of sutures may be covered with loose pads of bichloride or sterilized gauze. When a number of these layers have been applied, larger pieces of gauze, composed of a number of layers, are laid upon the stump, covering it thoroughly in all directions, and over the gauze are applied a few layers of sterilized or sublimated cotton. This dressing is held in position by a recurrent gauze bandage. Compression of the tissues of the stump by a firmly applied bandage prevents oozing

and controls muscular spasm. The application of a splint often conduces to the patient's comfort. When the stump has been dressed in this manner it is placed in a moderately elevated position upon a soft pillow.

After-Treatment of Amputations.—The after-treatment in cases of amputation, if reaction has been established and shock does not occur after the operation, is usually very simple. The patient should be given a moderate amount of stimulant, according to the condition of his pulse, should be kept quietly in the recumbent position with the head low, and should be given for the first few days liquid diet.

Dressing of Stumps.—If the patient has no elevation of temperature and no other evidence that the wound is not running a perfectly aseptic course, we are not in the habit of dressing the stump until the seventh day, even if drainage has been introduced. At this time the materials for dressings should be prepared; a rubber blanket covered with sterilized towels should be slipped under the stump, and the bandage should be divided with scissors before the stump is lifted from its pillow. The stump then being carefully raised by an assistant, the dressings are removed, and the surface may be irrigated with a bichloride solution or with sterilized water; the drainage-tube is removed, and if the appearance of the stump is satisfactory, there being no tension from the sutures, a sterilized or antiseptic dressing is applied in the same manner as the primary dressing, after which the stump is allowed to rest for another week without dressing. Of course the greatest possible care should be exercised as regards asepsis in the redressing of stumps. At the expiration of the second week the dressings are removed, and by this time union is usually so far advanced that the sutures may be removed. A light antiseptic dressing is then applied, and the patient is allowed to sit up in bed, or, in case of amputation of the hands or feet, may even be allowed to leave his bed.

This description applies to a case which runs an aseptic course after amputation; but, unfortunately, in spite of the greatest care, cases may run a different course, and numerous complications may be developed.

Complications after Amputation.—Shock.—This is an important and serious complication which may follow amputation. The treatment of the condition has already been described.

Intermediary or Consecutive Hemorrhage.—In spite of the greatest care in securing the blood-vessels at the time of operation, often a number of small vessels escape observation, which do not bleed at the time of operation, but bleed after reaction has been established, and as a result of this blood escapes through the drainage-tubes, and if drainage has not been employed the stump becomes stuffed with blood-clots and bloody serum escapes between the flaps. The presence of consecutive hemorrhage is shown by the soaking of the dressings with blood and serum, or occasionally the dressings contain blood-clots.

Treatment.—This consists in elevating the stump and applying pressure by means of a compress and a bandage. If in spite of this treatment the stump becomes painful and the oozing continues, it is wiser to remove the dressings, open the stump, remove the clots, and irrigate the stump with sterilized water as hot as can be borne by the patient. If bleeding vessels

can be discovered they should be ligatured, but if the oozing is capillary the application of hot water will often check it. After the bleeding has ceased the flaps should be approximated by sutures and the stump dressed as previously described.

Secondary Hemorrhage.—This complication is fortunately very infrequent after amputations where due regard to asepsis has been observed. If secondary hemorrhage, however, does occur, warning is usually given by one or two slight preliminary bleedings. These should put the surgeon upon his guard, and the patient should be carefully watched by a skilled assistant who is able to apply the tourniquet or make judicious compression in case the hemorrhage becomes profuse.

Treatment.—When free hemorrhage occurs, the tourniquet should be applied and the dressings removed, and the stump should be opened and the bleeding vessel sought for in the wound and secured by a ligature; the stump should then be closed and dressed. If secondary hemorrhage again occurs, the same procedure should be repeated, and the vessel should be secured in the wound if possible. If, however, it is impossible to secure the vessel in the wound, or if the hemorrhage again recurs after the vessel has been secured, the main artery should be ligated above the wound at the point of election.

Gangrene of the Stump.—This complication sometimes occurs in stumps after amputations, and may result from impaired nutrition of the flaps due to the primary injury, or may be caused by the presence of infective organisms. All surgeons of experience recognize the fact that in amputations for traumatism it is extremely difficult to differentiate accurately vitalized from partially devitalized tissues, and in spite of the greatest care some tissue may be included in the flaps which does not possess sufficient vitality. There are also certain conditions, such as diabetes, Bright's disease, and atheroma, which predispose to gangrene. Gangrene may also, as previously stated, result from infection, and may occur in the form of *traumatic spreading gangrene*. Limited gangrene of a flap or a portion of a flap resulting from the original traumatism is not a very serious complication; the dead tissue in time separates and leaves a healthy granulating surface, and in many cases a satisfactory stump results after cicatrization has occurred. Extensive gangrene involving the whole stump is a very serious condition, and is often followed by a fatal termination. If this does occur, as soon as the gangrene is well established and a line of separation has formed amputation should be performed at a higher point. In traumatic spreading gangrene, prompt amputation at a higher point alone gives the patient a chance of recovery.

Septic Infection.—Septic infection, resulting in osteomyelitis, septicæmia, or pyæmia, is also a complication which may occur after amputation, and is a very fatal one. In the case of *osteomyelitis* involving the stump, the treatment which offers the patient the best chance of recovery consists in opening the stump and exposing the bone by a lateral incision from the angle of the flaps; the bone should then be freely opened with a gouge and the medullary cavity thoroughly exposed, and all diseased tissues should be removed with the gouge and curette. If recovery takes place after osteo-

myelitis of the stump, more or less necrosis of the bone usually results. *Erysipelas* may also occur in stumps, and may result in serious consequences.

Mortality after Amputations.—This is influenced by various conditions, among which may be mentioned the nature of the injury, the age of the patient, and the various constitutional conditions which affect unfavorably other operations as well as amputations. The locality of the amputation is important in this connection, amputations of the lower extremities being more fatal, as a rule, than those of the upper extremity, and all amputations increasing in gravity as the point of amputation approaches the trunk. Amputations for acute affections of the bones are more fatal than those for chronic diseases of the same parts. Formerly many deaths after amputation were due to septic infection, which, however, at the present time has been reduced to a minimum by the improved methods of wound treatment. The loss of blood in certain amputations, as those of the hip- and shoulder-joints, was frequently a cause of death, but the mortality following these operations has been very much diminished by the use of some of the recently introduced methods of controlling hemorrhage, and indeed in all amputations the general introduction of the method of controlling bleeding during the operation by elastic constriction has done much to reduce the mortality. If after amputation the patient escapes the primary danger from shock, and if due care has been taken as regards asepsis, the prognosis is good, as wound complications are of infrequent occurrence.

Affections of Stumps.—After the cicatrization of the stump it continues to undergo changes in structure for a long time; the muscles waste and are converted into dense fibro-cellular tissue; the same changes occur in the tendons; the bone is rounded off and its medullary cavity becomes filled up; the vessels are obliterated to a certain distance and are converted into fibrous cords; the nerves become thickened or bulbous at their extremities, and in time the whole stump becomes more or less wasted.

Spasm of Muscles.—This affection is sometimes observed after amputation, and usually occurs shortly after the operation. The most marked cases of this condition, however, occur where amputations have been performed in patients suffering from chorea; in other cases persistent or choreic spasms have developed after stumps have permanently healed.

Mechanical Ulcer.—This consists in a chronic form of ulceration at the end of a stump, and generally results from insufficient flaps or from undue retraction of the muscles after amputation has been performed. Mechanical ulcer may be treated by bandaging, by the application of an extension apparatus, or by re-amputation.

Conical Stump.—This is chiefly seen in amputations of the upper part of the arm or leg in children, and does not, as a rule, result from the flaps having been of insufficient length, but is accounted for by the physiological fact that the principal growth of the arm is from the upper epiphysis of the humerus, and that of the leg from the upper epiphysis of the tibia, and, as the growth of the bone from these epiphyses is more active than that of the surrounding soft parts, the bone is projected through the parts and produces a typical conical stump. (Figs. 194, 195.) A conical stump generally requires re-amputation.

Neuroma.—This is a painful enlargement of the nerves of a stump which is not infrequent, and is said to depend not so much upon the bulbous enlargement of the nerves as on a sclerotic condition of the same, giving rise to neuritis, which results from inflammatory changes. If, however,

Fig. 194.

Conical stump after amputation of arm.

Fig. 195.

Conical stumps after amputation of the legs. (Agnew.)

any distinct painful enlargements of the nerves can be felt in the stump, they should be removed by incision, or re-amputation of the stump may be necessary if the condition gives the patient great discomfort.

Contraction of Tendons.—Occasionally in certain amputations about the foot the stump is distorted by the contraction of tendons and is rendered practically useless. In such cases subcutaneous division of the tendons may be required. After Chopart's amputation of the foot, contraction of the muscles attached to the os calcis by the tendo Achillis may cause distortion of the stump, so that the cicatrix is pressed upon and becomes painful, or may produce so much distortion that a shoe cannot be worn. In such a case tenotomy of the tendo Achillis may be required.

Necrosis.—This condition may be present after operation, and may result, as previously stated, from osteomyelitis. In such a case, as a rule, the amount of bone destroyed is extensive, and a long tubular sequestrum forms, which may require removal subsequently. (Fig. 196.) On the other hand, a limited amount of necrosis may result, unattended with any marked constitutional disturbances, which is probably due to the injury produced by the saw at the time of the division of the bone.

Fig. 196.

Tubular sequestrum from stump. (Agnew.)

MULTIPLE AMPUTATIONS.

In multiple injuries of the extremities it occasionally becomes necessary to remove two or more limbs at the same time by primary amputation. The cases calling for multiple amputation usually result from machinery

accidents, railroad crushes, gunshot injuries, or from frost-bites, burns, and scalds; in the latter cases secondary amputation is resorted to. The majority of cases receiving injuries of sufficient gravity to demand multiple amputation usually die of hemorrhage, or are in so profound a condition of shock when they come under the care of the surgeon that any operative treatment cannot be undertaken; reaction in these cases is unusual, the patient generally dying of shock. In exceptional cases, where little blood has been lost as the result of the accident, and reaction has been established, primary amputation should be performed, and may be undertaken with a fair prospect of success. Recovery following double amputation is not uncommon, a number of cases in which parts of three limbs have been removed simultaneously have been reported, and a few cases in which quadruple amputation has been practised have terminated successfully. The nearer the damage to the limbs approaches the trunk the less is the chance that reaction will occur. Ashhurst's remarkable case of primary simultaneous amputation at the hip-joint and of the leg, in which recovery followed, shows that if reaction from shock in these cases takes place, a successful result need not be despaired of.

In multiple amputations required for the results of frost-bites, burns, and scalds, or for gangrene, synchronous amputation is not always demanded, and the parts may be removed at intervals of a few days or weeks. The shock of the operations is thus very much lessened, and the results in these cases are naturally more favorable than in cases where multiple synchronous amputations are demanded.

Multiple Simultaneous or Synchronous, or Consecutive Amputations.—Some difference of opinion exists among surgeons as to the best method of procedure in these cases to diminish the shock of the operation itself. It has been recommended that the amputation be done synchronously or simultaneously—that is, two or more surgeons each removing a limb at the same time; this method certainly diminishes the time required, but in our judgment does not diminish the amount of shock, but rather aggravates it for a short time during the operative procedure. We have in these cases adopted the consecutive method, which is that recommended by Ashhurst, and consists in performing first the amputation which is likely to be followed by the most shock, and if the patient's condition after this has been done warrants it, the next most serious amputation is performed, and after this the third or fourth amputation may be undertaken. For instance, in a case of crush of the thigh, leg, and arm, the thigh should be amputated first, next the leg, and last the arm.

Fig. 197.

Triple amputation.

This method of procedure we employed in a case of triple amputation for railroad crush, which ended in recovery. (Fig. 197.) The time occupied in the operations should be as short as possible, to avoid the development of shock and the disadvantages of prolonged anæsthesia. With this end in view, after removing the first limb, the main vessels should be secured by ligatures and the stump wrapped in a bichloride towel, and the same procedure repeated for the next stump; when all have been amputated, any remaining vessels are secured, and the stumps are closed and dressed. If after removing one or more limbs the surgeon finds that the patient's condition has markedly failed, as evidenced by the condition of the pulse and temperature, it is wise to postpone further operative procedure and treat the patient actively for the relief of shock, adopting rather the consecutive than the synchronous method of amputation. When reaction has occurred, even if it be after some hours, the remaining amputation or amputations may be undertaken with a much more favorable prospect. We have successfully adopted this method in multiple amputations.

SPECIAL AMPUTATIONS.

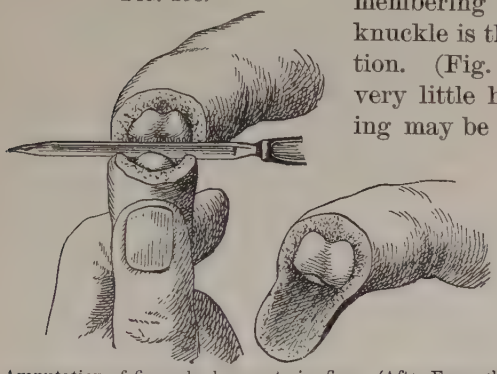
AMPUTATIONS OF THE UPPER EXTREMITY.

In all amputations involving the phalanges and metacarpal bones the rule is observed to save as much of the bone as possible, as no mechanical contrivance can possibly equal the natural utility of the hand. The possibility of saving badly damaged portions of the hand has also been greatly increased by the modern methods of wound treatment. The fingers are very seldom amputated unless their destruction by the injury is complete; a small amount of vitalized tissue will often in these cases keep up the nutrition of the finger, and ultimately recovery with a more or less useful finger may result. It was formerly the rule in the case of the middle fingers, when it became necessary to go as high as the proximal interphalangeal joint, as there is no special flexor tendon for the proximal phalanx, to amputate at the metacarpo-phalangeal joint. At the present time, when it is recognized that the interossei flex the proximal phalanx, the old rule is disregarded, and amputations at the proximal interphalangeal joint may be undertaken with satisfactory results.

Amputation of the Phalanges of the Fingers.—Amputation of the phalanges may be rendered necessary by injuries or by diseases of the bones. The phalanges may be amputated in their continuity or in their contiguity. As it is important to save as much as possible of the finger, the former method is generally to be employed instead of disarticulation. Amputations for necrosis of the distal phalanx are now seldom performed; it is found better in these cases to expose the dead bone and enucleate it, leaving the soft parts and the nail, which procedure, although it leaves a somewhat misshapen finger, serves to prolong the finger, and thus to preserve its usefulness. Amputation in the continuity of the phalanx may be performed by making antero-posterior flaps; a short dorsal flap is first cut from without inward, and a long palmar flap is cut in the same manner; the bone is then divided with a small metacarpal saw or with

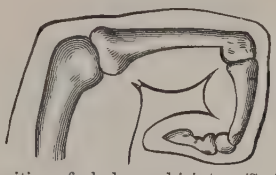
bone-cutting forceps. Amputations in the contiguity are performed by making a short posterior flap, opening the joint, and then making a long anterior flap. (Fig. 198.) In disarticulations of the phalanges the position of the joint may always be recognized by remembering that when the finger is flexed the knuckle is the upper boundary of the articulation. (Fig. 199.) In amputating the fingers very little hemorrhage occurs, and the bleeding may be satisfactorily controlled by an assistant making digital compression upon the radial and ulnar arteries, or a rubber drainage-tube may be wrapped several times around the wrist, which will satisfactorily control the bleeding. After the finger has been removed the digital arteries usually require the application of ligatures, or, if hemorrhage is not free from these vessels, the surgeon may control bleeding from them by the stitches which hold the flaps in apposition. After controlling the bleeding, the flaps are brought together by sutures applied at three or four points; a gauze dressing is then applied to the stump, and the hand should be placed upon a palmar splint to keep the parts absolutely at rest. At the end of a week or ten days union is usually complete, and all dressings may be dispensed with.

Fig. 198.



Amputation of finger by long anterior flap. (After Esmarch.)

Fig. 199.



Position of phalangeal joints. (Smith.)

Amputations of the Phalanges of the Thumb are performed in the same manner as amputations of those of the fingers.

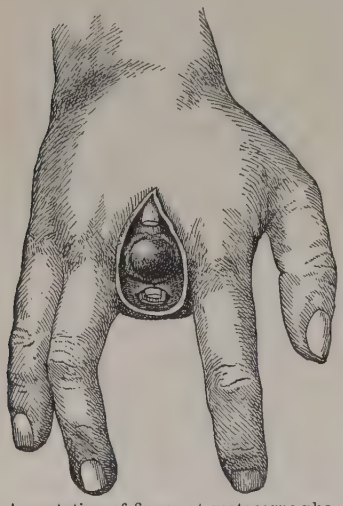
Metacarpo-Phalangeal Amputations.—In amputating at the metacarpo-phalangeal joints the hand should be placed in the pronated position, and the sound fingers should be held out of the way by an assistant; the surgeon then grasps the injured finger, and, entering the point of the knife directly in front of the middle of the knuckle, carries it at once to the bone, making his incision directly forward for a short distance, then diverging to one side and passing through the interdigital cleft to the palm. A similar cut is made on the opposite side, the two incisions uniting on the palmar surface of the finger opposite the point of starting. (Fig. 200.) The lateral aspect of the joint is next opened by the point of the knife, the finger being carried strongly to the opposite side, to make the ligaments tense and the articulation

Fig. 200.

Incision for metacarpo-phalangeal amputation. (Agnew.)

gape. The lateral ligaments of the opposite side are next divided, and the disarticulation is completed. The wound resulting after disarticulation is represented in Fig. 201. To make the deformity less after disarticulating a finger at this joint, it has been recommended that the head of the metacarpal bone be also removed with bone forceps, so that the remaining metacarpal bones may come closer together; this has the disadvantage, however, of weakening the hand, and, as the head of the metacarpal bone in time atrophies to a certain extent, causing the gap between the fingers to be less marked, the procedure is not to be recommended.

Fig. 201.



Amputation of finger at metacarpo-phalangeal joint. (After Rotter.)

Amputations of the Metacarpal Bones.—The removal of the whole or a part of a metacarpal bone, with its corresponding finger, may be required in consequence of injury or disease. The operation is done by making a dorsal incision, commencing at the carpal extremity of the metacarpal bone and carrying it forward to the knuckle; at this point the direction of the knife is changed, and it is carried towards the interdigital cleft into the palm, where it joins a similar cut made upon the opposite side; the soft parts should next be dissected free from the dorsal and lateral aspects of the bone, and the ligaments uniting the anterior extremity of the bone to the adjoining metacarpal bones should be divided, when the finger can be drawn backward, which raises the metacarpal bone from its bed and allows it to be detached from the soft parts connected with its anterior surface. In amputating the metacarpal bones it is advisable to divide the bones, leaving the carpal ends in place in order to avoid opening the wrist-joint, except in the case of the first and fifth metacarpal bones, which do not communicate with the others and with the synovial sacs. In dividing or disarticulating the carpal ends of the bones, great care should be taken to avoid injury of the vessels of the palm.

Amputations of the Thumb and its Metacarpal Bone.—In performing this amputation care should be taken to preserve the entire mass of muscles on the thenar aspect of the hand, to leave a surface against which the fingers may impinge. An incision is started at the junction of the metacarpal bone with the carpus, on the dorsal surface of the thumb, and is carried down through the web between the thumb and the forefinger. A corresponding incision is made upon the opposite side, which joins the first incision, and the bone is cleared and raised from its bed and is disarticulated at its proximal extremity. (Fig. 202.) Another method of performing this amputation is to make first a dorsal incision and carry it down to the web between the thumb and the forefinger; the palmar flap is then made by thrusting the knife upward to its point of entrance and cutting downward and outward. In amputating the right thumb with the meta-

carpal bone, it is better to make the palmar flap first by transfixion, the dorsal flap being made subsequently. (Fig. 203.) In this operation it is also necessary to keep the point of the knife close to the bone.

Fig. 202.

Amputation of thumb—racket-shaped incision. (Agnew.)

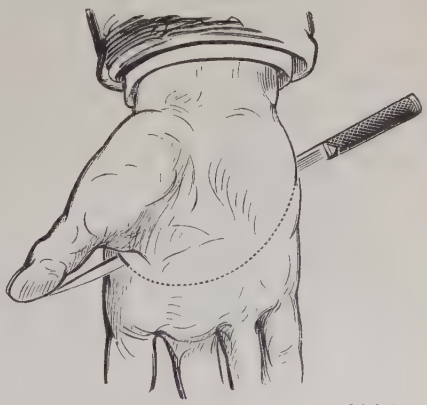
Fig. 203.

Amputation of thumb by transfixing anterior flap.

Amputation of the Little Finger and its Metacarpal Bone.—In amputating the fifth metacarpal bone an incision should be made along the inner border of the hand, and carried down to the bone between the skin and the abductor minimi digiti muscle; the lower end of the incision passes over the knuckle to the web of the finger, and backward under the palmar surface to join the first incision. The ligaments attaching the bone to its fellow should next be divided, and the bone should be raised from its bed and separated from the soft parts and disarticulated at its proximal extremity. After controlling the bleeding, the wound should be brought together by a few interrupted sutures.

Amputation of the Hand at the Carpo-Metacarpal Joint.—Amputation of the hand at the carpo-metacarpal joint or between the rows of the carpal bones is occasionally resorted to. This procedure is not, as a rule, to be recommended, as the carpal bones are apt subsequently to become diseased and require removal. When this operation is performed, the hand should be placed in a state of extreme supination, and the point of a narrow knife should be entered on the palmar aspect of the hand, opposite the articulation of the metacarpal bone of the little finger with the unciform bone, and pushed directly across the hand, between the bones and the soft parts, until its point emerges below the thumb (Fig. 204); the knife should then be carried downward, close to the metacarpal bones, and an elliptical flap

Fig. 204.



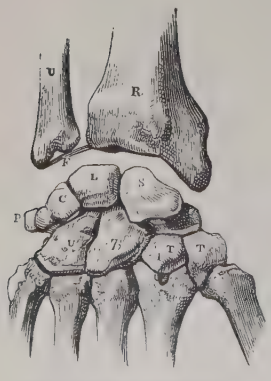
Amputation of hand at carpo-metacarpal joint. (Agnew.)

should be cut; the hand being turned into a state of pronation, a semicircular incision should be made across its dorsal surface, three-fourths of an inch below the carpo-metacarpal articulation, joining the anterior incision at the inner and outer margins of the hand. The flaps are next turned back and the metacarpal bones are disarticulated.

Informal Amputations of the Fingers and Hand.—It is well for the surgeon to bear in mind the formal amputations of the fingers and hand, but, owing to the very irregular manner in which the soft parts and the bones of the fingers and hand are injured in wounds, it is often impossible to practise any of these formal amputations. In such cases the surgeon has an opportunity of displaying his ingenuity in the method of securing flaps to cover the bones after the removal of the injured parts. Partial amputations of the hand, removing several of the fingers with their metacarpal bones, often leave a most useful member. If the thumb and index finger can be saved, the portion of the hand remaining is much more useful than any artificial apparatus. In the same way, if the fingers are removed at the metacarpo-phalangeal articulation and the thumb can be saved, a very useful hand results. In cases where the thumb and little finger can be saved, and the rest of the fingers require removal, a satisfactory result is obtained. In extensive laceration of the hand, accompanied by injuries of the fingers, where a number of fingers require amputation, if any sound skin is present upon the fingers, this should be stripped off to form a flap to cover the raw surface upon the hand. Occasionally also it is possible to shift the finger to a sound metacarpal bone where a finger has been amputated and an injured metacarpal bone has required removal. No fixed rule for these various procedures can be given; the surgeon has simply to exercise his judgment as to the best disposition of the material he has before him.

After all amputations of the fingers or of the metacarpal bones the flaps should be loosely brought together with sutures, and a gauze dressing should be applied and the parts placed at rest upon a palmar splint. Repair after operations upon the hand, by reason of its great vascularity, is usually rapid.

Fig. 205.



Radio-carpal articulation.

Amputations at the Wrist.—The hand should be removed at the radio-carpal joint, where it is possible, rather than by amputation above this joint, for by amputation at the wrist the motions of pronation and supination may be preserved, although this is not invariably the case. In disarticulating at the wrist it should be remembered that the styloid processes of the ulna and the radius form the inner and outer borders of the carpal arch, and that the bones of the first row of the carpus, the scaphoid, semilunar, and cuneiform, are arranged so as to present a convex surface adapted to the concavity of the bones of the forearm. (Fig. 205.) In amputations at the wrist or those of the forearm, the bleeding is controlled by the application of a tourniquet or an elastic strap to the brachial artery at the middle of the

arm. In amputating at the wrist-joint antero-posterior flaps are usually employed. The hand should be held in the pronated position and somewhat flexed; a curved incision is made from one styloid process to the other, and a convex flap an inch and a half in length is turned up from the back of the hand. (Fig. 206.) The hand is then strongly flexed, and the posterior radio-carpal ligament is divided. The joint being exposed, the knife is next applied to the lateral ligaments, and when the joint is freely opened, the knife is carried through it and made to shape an anterior or palmar flap by cutting downward and outward. (Fig. 207.) This anterior or palmar flap

Fig. 206.

Lines of incision in amputation at the wrist. (Agnew.)

Fig. 207.

Disarticulation at the wrist. (Agnew.)

should be longer than the posterior flap. After disarticulation of the hand the tips of the styloid processes may be removed with a saw or with bone forceps, although their removal is not absolutely necessary. The vessels requiring ligature in amputations at the wrist are the radial, ulnar, and interosseous arteries.

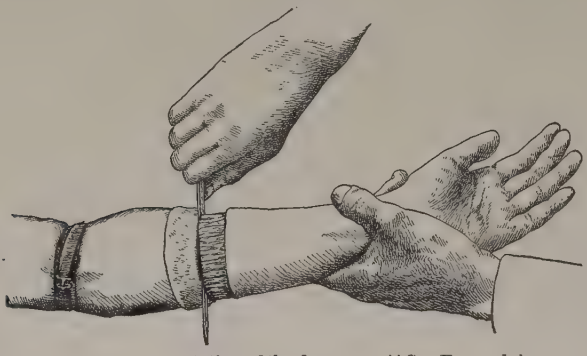
Amputations of the Forearm.—The forearm may require amputation at any point between the wrist and the elbow, and the circular, the modified circular or oval method, which consists in oval skin-flaps with circular division of the muscles, or the method by rectangular flaps (Teale's) may be employed. At the lower portion of the forearm the circular method is that usually employed. In the upper portion of the forearm the modified circular method is most satisfactory.

Circular Method.—In performing this operation a circular incision of the skin and cellular tissue is made, and a cuff is dissected up for about two inches, the muscles and interosseous membrane being cut through; a three-tailed retractor is next applied, and the bones are divided with a saw. (Fig. 208.) The tendons are apt to project from the surface of the stump, and they should be drawn down and retrenched. The principal arteries requiring ligatures are the ulnar, radial, and anterior and posterior interosseous: a few muscular branches may also require ligation. The median, radial, and ulnar nerves should also be drawn out and retrenched.

Modified Circular or Oval Method.—Amputation of the forearm by this method is very frequently resorted to. It consists in first dissecting up

two oval antero-posterior flaps of skin and cellular tissue, and then, having retracted these, the muscles are cut through by a circular incision, and the bones are subsequently divided with a saw. (Fig. 209.)

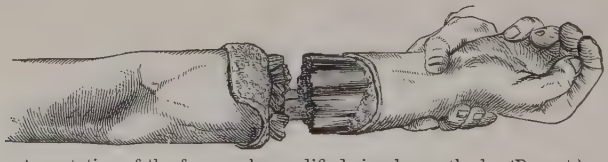
Fig. 208.



Circular amputation of the forearm. (After Esmarch.)

Teale's Method.—Teale's method is sometimes employed in amputations of the forearm, but possesses no advantages over the methods previously described.

Fig. 209.

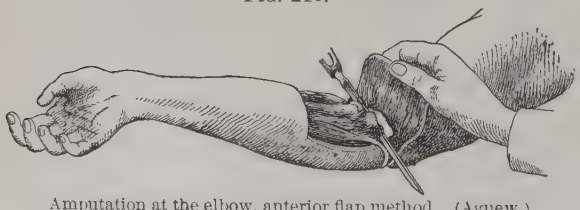


Amputation of the forearm by modified circular method. (Bryant.)

Amputations at the Elbow.—The methods of amputating at the elbow are the anterior flap, the elliptical incision, the lateral flap, and the circular method.

Anterior Flap Method.—A flap three inches in length, its base parallel to and half an inch below the condyles of the humerus, is cut by transfixion or from without inward. (Fig. 210.) The joint is next opened and the lateral ligaments are divided. The olecranon is then exposed, the attachments of the triceps are separated, and a posterior flap is cut from without inward or from within outward a little below the line of the condyles.

Fig. 210.

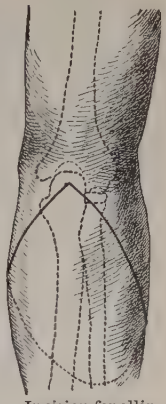


Amputation at the elbow, anterior flap method. (Agnew.)

The Elliptical Method.—In this method of amputating at the elbow an incision is carried from the olecranon process downward and forward to a point a little above the middle of the forearm. The incision is then continued

across the anterior aspect of the limb, and is carried back to the olecranon process. (Fig. 211.) The incision involves only the skin and the cellular tissue. The flap having been dissected up for a short distance, the soft parts close to the joint are transfixed; the muscles are cut obliquely, so that an anterior flap is formed. This flap is held up, the bones are disarticulated, the attachment of the triceps tendon to the olecranon is divided, and any tissues which have escaped division along the posterior aspect of the limb are severed. After the vessels have been secured, the flap is turned over and sutured, and a curved cicatrix on the posterior aspect of the limb results.

FIG. 211.

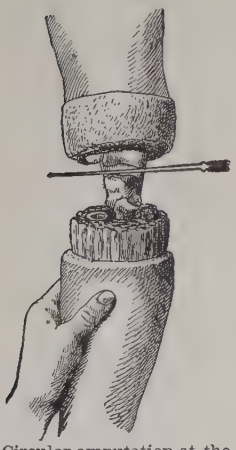


Incision for elliptical amputation at the elbow. (After Treves.)

Lateral Flap Method.—Amputations at the elbow may also be performed by the lateral flap method, in which the flaps are cut either from without inward or by transfixion. An external flap three inches in length is made on the outer side of the arm, starting from a point a finger-breadth below the bend of the elbow, by transfixion or by cutting from without inward. A shorter internal flap is next cut in the same manner, and the joint is opened and the disarticulation effected. The *circular* method may also be employed in this amputation. (Fig. 212.)

Amputation of the Arm.—The arm may be amputated at any point below the attachment of the muscles at the axilla by the circular, the oval, the transfixion, or Teale's method. Although these various systematic methods of removing the arm are often practised, it is sometimes found impossible, from the character of the injury, to employ any of them, and in such cases flaps have to be fashioned according to the tissue which is present, the rule, however, being to save as much of the arm as possible. It is always considered advisable to save even a small portion of the bone, which may consist only of the head and a portion of the neck of the humerus, as by so doing the rotundity of the shoulder is preserved, and the deformity is not so marked as it would be if the arm were amputated at the shoulder-joint. An artificial arm can also be better adapted to a stump of some length.

FIG. 212.



Circular amputation at the elbow. (After Esmarch.)

FIG. 213.

Stump after circular amputation at the elbow. (After Esmarch.)

To control hemorrhage during amputation of the arm at its middle or lower third the tourniquet with a compress should be applied along the inner edge of the biceps or coraco-brachialis muscle, or the elastic strap of Esmarch's apparatus may be employed. When, however, the arm is ampu-

tated in its upper third, to control the bleeding a bandage should be placed in the axilla over the artery, and a tourniquet applied over this, resting upon the acromion process. Hemorrhage in high amputations of the arm may also be controlled by the application of a compress, with the elastic strap of Esmarch's apparatus applied over it, the strap being crossed high over the shoulder and fastened in the opposite axilla, or Wyeth's pins and an elastic strap may be employed. The method of applying these will be described under amputations at the shoulder-joint.

Circular Method.—This method is usually employed in amputations in the lower third of the arm. The arm is abducted, and the surgeon, with a circular sweep of the knife, divides the skin and cellular tissue for about three-fourths of the circumference of the arm; the remaining undivided skin is then severed, and, as the skin upon the anterior and internal surface of the arm retracts more than that upon the posterior surface, the circular incision should extend somewhat lower upon the anterior than upon the posterior surface. The skin and cellular tissue having been divided, an assistant retracts them forcibly, and the surgeon makes a circular incision of the muscles down to the bone on a line with the upper edge of the divided skin. The bone is then thoroughly cleared, and great care should be taken that the musculo-spiral nerve, which lies in a groove in the bone, is cleanly divided. Having incised the muscles and cleared the bone, a two-tailed retractor is applied, the muscles and skin-flaps are held back, and the bone is divided with a saw. The vessels which require ligatures in amputation of the lower third of the arm are the brachial artery, which lies to the inner side with the median nerve; the superior profunda, which lies upon the posterior external aspect of the bone with the musculo-spiral nerve; and the inferior profunda, to the inner side of the brachial with the ulnar nerve. In muscular arms, in addition, several muscular branches will also require ligatures. In all amputations of the arm it is well to remember the possibility of a high division of the brachial artery, and to see that the abnormal vessel is properly secured if present. The nerves should be drawn out and retrenched. After all bleeding has been controlled a drainage-tube is introduced, and the flaps are brought together vertically, to secure free drainage.

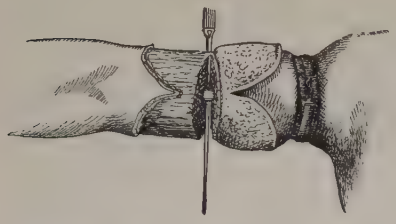
Oval or Modified Circular Method.—In this method of amputation of the arm, antero-posterior oval flaps of skin and cellular tissue are made, the anterior flap being slightly longer than the posterior one. These flaps are dissected up for a sufficient distance, when a circular incision is made, dividing all the tissues down to the bone; a retractor is next applied, and the bone is divided with a saw. (Fig. 214.) Lateral flaps as well as antero-posterior flaps may be employed in amputating the arm.

Method by Transfixion.—Owing to the central position of the bone in the arm, the method by transfixion is preferred by many operators; it is also a method by which amputation can be most rapidly performed. (Fig. 215.) The arm being grasped with the hand, the point of a medium-sized amputating-knife is thrust through the arm so as to pass over the humerus and make its exit at a corresponding point on the skin of the opposite side; a flap of sufficient length is next cut from within outward.

The knife is then passed behind the bone, and a posterior flap is cut in the same manner. The bone is next cleared of any muscular tissue which remains, the flaps are retracted, and it is divided with a saw.

Teale's method is sometimes employed in amputations at the middle and lower thirds of the arm. The incisions forming

Fig. 214.



Modified circular amputation of the arm. (After Esmarch.)

Fig. 215.

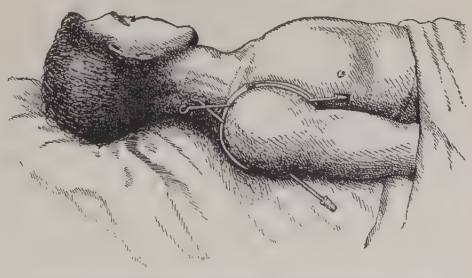
Amputation of the arm by transfixion. (Bryant.)

the long anterior flap should be made in such a manner that the inner one clears the margins of the biceps muscle so as not to involve the brachial artery; the short flap is taken from the posterior aspect of the arm.

Amputations at the Shoulder-Joint.—The disarticulation of the arm at the shoulder-joint may be effected in several ways. The methods most commonly employed are the oval, or Larrey's; the flap, or Dupuytren's; the double flap, or Lisfranc's, and Spence's.

The great risk which formerly accompanied amputations at the shoulder-joint arose from the difficulty in controlling the hemorrhage during the operation. This was effected by a padded key pressed upon the subclavian artery above the clavicle, or by an assistant grasping the axillary vessels before their final division was accomplished. At the present time the use of Wyeth's pins and an elastic strap (Fig. 216) is found the most satisfactory method of controlling hemorrhage during amputation at the shoulder-joint. When this method is employed, stout steel pins or skewers about ten inches in length should be used; the anterior pin is passed through the tissues in front of the acromion process, and is brought out through the anterior fold of the axilla; the posterior pin is passed behind the acromion process, and is brought out through the posterior fold of the axilla. The rubber strap or tube is then wrapped around the shoulder behind the pins and secured. If this method of controlling hemorrhage is not employed, a compress in the axilla, held by an elastic

Fig. 216.

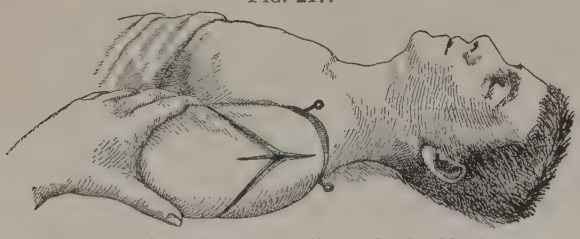


Pins and elastic strap applied for amputation at the shoulder-joint.

strap, the ends of which are crossed high up upon the shoulder and passed to the opposite axilla, may be used.

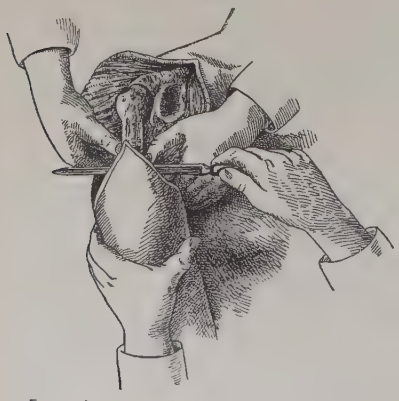
Oval, or Larrey's Method.—In this method of amputation, which is that most generally employed, the arm should be held a short distance from the body; the point of the knife is entered just below the acromion process, and a deep incision three inches in length is made down to the head of the bone along the axis of the arm; from the middle of this incision two others are made, one on each side, obliquely downward to the point where the anterior and posterior folds of the axilla end in the tissues of the arm (Fig. 217); the latter incisions should be only deep enough to divide the skin and superficial fascia. The flaps are then dissected up until the head of the bone is well exposed, and after opening the capsule and dividing the muscles inserted into the neck and the tuberosity of the humerus, which may be facilitated by rotating the head of the bone outward and inward, the disarticulation is effected by adducting the elbow and passing the knife downward behind the bone and cutting outward in the line of the cutaneous incisions. (Fig. 218.) After securing the axillary

Fig. 217.



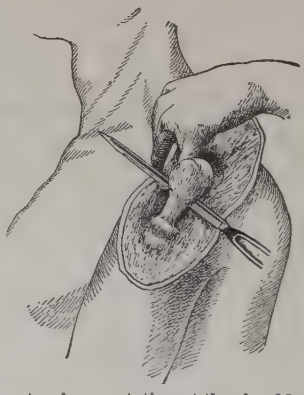
Incisions for Larrey's amputation at the shoulder-jont.

Fig. 218.



Larrey's amputation at the shoulder-joint.

Fig. 219.



Dupuytren's amputation at the shoulder-joint.

artery and axillary vein, the anterior and posterior circumflex arteries, and any muscular branches which bleed, the flaps should be brought together vertically.

In securing the dressing to the wounds after amputations at the shoulder-joint, a few recurrent and circular turns of a bandage are applied, and the turns of the bandage are carried over the stump and to the opposite axilla, a number of these turns being employed, and the bandage is finished with a few circular turns.

The Flap, or Dupuytren's Method.—In this amputation, the arm being abducted to a right angle with the body, the flaps may be cut by transfixion or from without inward; the external or large flap embraces the greater part of the deltoid muscle, and the smaller or short flap is cut from the inside of the arm after the head of the bone has been disarticulated. When amputating by transfixion, the surgeon pinches up the thick cushion of flesh overlying the shoulder; the point of a narrow knife should be entered an inch in front of the acromion process and pushed across the outer aspect of the head of the humerus, shaving, if possible, the capsule, and brought out at the posterior fold of the axilla; the knife is then made to cut downward until a large deltoid flap is formed; this flap is turned up and the head of the bone is disarticulated; the knife is then placed behind the bone and a short flap is cut, keeping close to the bone so that the vessels are divided with the last cut of the knife. (Fig. 219.)

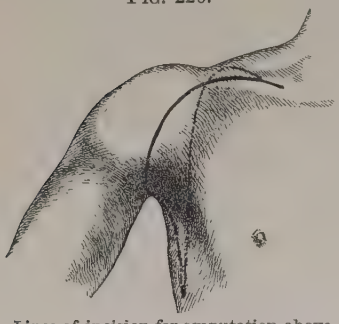
Double Flap, or Lisfranc's Method.—In this method of amputation at the shoulder-joint the point of the knife is entered at the outer side of the coracoid process and is carried across the outer aspect of the head of the humerus, being brought out a little below the posterior border of the acromion process, and a long flap is cut with its apex below. This flap is turned up, the attachments to the head of the bone are severed, and it is disarticulated. The knife is again entered behind the bone, and a long posterior flap is cut from within outward.

Spence's Method.—In this method of amputation at the shoulder-joint an incision is made down to the head of the humerus, immediately in front of the coracoid process, and is continued downward through the clavicular fibres of the deltoid and pectoralis major muscles until the attachment of the latter to the humerus is reached; the incision is next carried backward to the posterior fold of the axilla; an incision including only the skin and the cellular tissue is next made from the anterior portion of the first incision across the inside of the arm to meet the incision on the outer side; the outer flap thus formed is turned up, and the head of the bone is disarticulated. The operation is completed by dividing the remaining tissues on the axillary aspect.

Amputations above the Shoulder-Joint.—This form of amputation is sometimes required in extensive lacerations of the arm and the region of the shoulder, or in cases of growths which involve the shoulder-joint and the tissues above, and consists in the removal of the arm with a part or the whole of the scapula, and sometimes a portion of the clavicle. When the operation is done for injury, no definite lines of incision can be laid down, the practice being, as far as possible, to make the incisions in such a manner that the least possible amount of skin shall be sacrificed, so that a sufficient covering for the wound can be obtained. When done for the removal of growths involving the shoulder-joint, the incisions recommended by Treves may be employed. The patient should be placed on his back close to the edge of the operating-table. An incision should be made over the clavicle, extending from the inner extremity outward to a point a little beyond the acromio-clavicular articulation, which should be carried down to the bone; the clavicle being exposed, it should be divided

in its middle third or disarticulated from the sternum, and, its outer portion being lifted up, it is disarticulated at its acromial extremity. The subclavian vessels are thus exposed, and should be tied by two ligatures, about an inch apart, and the vessels should finally be divided between the ligatures. The axillary plexus of nerves should next be divided. The second incision is made at the centre of the first incision, and the knife is carried directly across the anterior part of the axilla and inner border of the arm to the inferior angle of the scapula; from the outer extremity

Fig. 220.



Lines of incision for amputation above the shoulder-joint. (Treves.)

Fig. 221.

Result of amputation above the shoulder-joint.

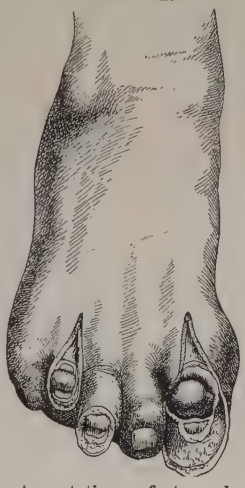
of the first incision over the clavicle a third incision should be made posteriorly, across the dorsum of the scapula to its inferior angle, joining the termination of the second incision. (Fig. 220.) Upon turning back the posterior flap thus formed and severing the connections of the scapula with the trunk and the muscular attachments which remain anteriorly, the upper extremity will be entirely freed from the trunk. Any small vessels which bleed should be secured, and, after introducing a drainage-tube, the flaps should be brought together with sutures; the wound when closed forms an oblique line running from above downward, outward, and backward; a copious gauze dressing should be applied and held in position by a bandage. The condition resulting from an amputation above the shoulder-joint is shown in Fig. 221.

AMPUTATIONS OF THE LOWER EXTREMITY.

Amputations of the Toes.—The amputation of a toe may be accomplished through the continuity of the phalanx, or an interphalangeal disarticulation may be effected; the latter is the preferable operation. Phalanges of the toes may be removed in the same manner as those of the fingers, by a racket-shaped incision. (Fig. 222.) It is better to amputate at the metatarso-phalangeal articulation than to attempt to remove them in front of this articulation, except in the case of the great toe, as the preservation of a portion of the other toes is often a discomfort rather than an advantage. Care should be taken to make the incision in such a manner that the resulting cicatrix shall not occupy the plantar surface; if, however, it is desired

to amputate a toe in the continuity of the phalanx, this is accomplished in the same manner as in the case of the fingers, by a short oval flap from the dorsal surface, and a long one from the plantar aspect of the toe. (Fig. 222.) It is well to remember that the web of the toes is considerably below the position of the metatarso-phalangeal joint. (Fig. 223.)

Fig. 222.



Amputation of toes by racket-shaped incision and flap method. (After Rotter.)

Fig. 223.

Relation of the metatarso-phalangeal joint to web of the toes. (Stimson.)

Metatarso-Phalangeal Amputation of the Toes.—A single toe is usually removed by an incision on the dorsal surface, beginning a little above the joint, and carried downward for about an inch; the incision, which is made down to the bone, then diverges into the web, and is carried under the toe and back on the other side to the point of divergence. (Fig. 222.)

Amputation of Two Adjoining Toes.—A dorsal incision should be made in the intermetatarsal space, just below the level of the joint, and carried down to the beginning of the web, then over the toe to the beginning of the adjoining web, then under the plantar surface of both toes in the line of the digito-plantar fold, through the web, and back to the point of divergence; the disarticulation of the toes is then effected, and, after controlling bleeding by the use of ligatures, the flaps are brought together with sutures.

Amputation of the Great Toe.—Amputation of the great toe may be accomplished by means of the racket-shaped incision employed in amputation of the other toes (Fig. 222), or by means of the lateral flap. In the latter case the knife is made to enter the joint by cutting through the commissure, aud the operation is completed by carrying the knife through the joint and along the outer side of the toe, forming a flap of the required size. The great toe may also be amputated by means of a short dorsal flap and a long plantar flap. In amputating the great toe, unless care is taken to make the flaps sufficiently voluminous, difficulty may be found in providing sufficient covering for the expanded anterior extremity of the metatarsal bone; this should be covered by the flaps without making tension upon them, for it is better not to resect the end of this bone, as it interferes with the base of support for the foot.

Amputation of all the Toes.—It sometimes happens that by reason of crushes, frost-bites, or burns the removal of all the toes is required. This is accomplished by grasping the toes with the hand and making an incision across the phalangeal portion of the foot, from its outer to its inner border, as nearly as possible on a line with the free edge of the interdigital

webs of the toes. This flap is next dissected back as far as the articulations, each of which is opened upon its dorsal surface. (Fig. 224.) When all the bones have been disarticulated the toes are flexed, and the knife is carried behind the articulations to the plantar aspect of the foot and made to cut a flap from the under surface of the phalanges as far forward as the web of the toes. A number of metatarsal branches of the plantar arch will require ligatures, after which the flaps should be brought together and secured by sutures. The appearance of the stump after the removal of all the toes is shown in Fig. 225.

Fig. 224.

Amputation of all the toes. (After Esmarch.)

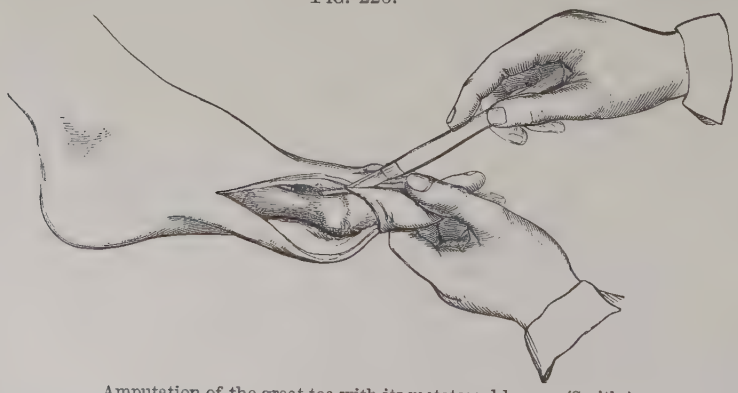
Amputation of the Metatarsal Bones.—In amputating the metatarsal bones it is better to leave the tarsal heads of the metatarsal bones in place and divide the bones with bone-pliers or a saw; in other words, to do an operation in continuity to prevent opening the tarsal articulations. In amputating, therefore, through the metatarsus, a short dorsal flap, slightly convex downward, is cut from one side of the foot to the other, and is dissected up; a long plantar flap is next cut in the same manner, and when this has been freed from the bones a saw is applied and the bones are divided. After securing any bleeding vessels the flaps are brought together with sutures, and the cicatrix will be upon the dorsum of the foot.

Fig. 225.

Stump resulting from amputation of the toes. (Agnew.)

Amputation of the Great Toe with its Metatarsal Bone.—In removing the great toe with its metatarsal bone an incision is made upon the

Fig. 226.



Amputation of the great toe with its metatarsal bone. (Smith.)

dorsal surface of the metatarsal bone, a little below the point at which the bone is to be divided, and is carried downward below the metatarso-phalan-

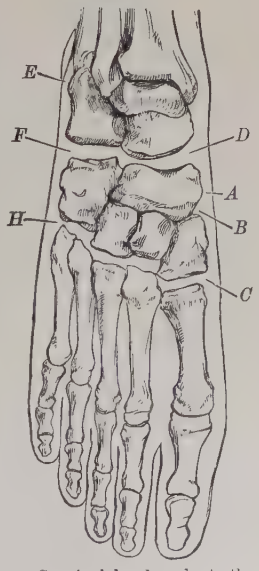
geal joint; it then diverges, passes under the toe, and comes back again to the point of divergence. (Fig. 226.) The bone is then exposed and cut through with bone-cutting forceps and a saw, or is disarticulated at the tarso-metatarsal joint and then lifted up and dissected loose from the tissues.

Amputation of the Fifth Metatarsal Bone.—The incision for the removal of the fifth metatarsal bone is made over the bone a little below the tarso-metatarsal articulation, is carried down and curved around the toe, and after the bone is exposed by dissecting back the flaps it is divided or disarticulated, and dissected out.

AMPUTATIONS OF THE FOOT.

At the present time some surgeons are inclined to think that the utility of partial amputations of the foot is questionable, and consider it a wiser procedure, where an amputation would be required through the tarsal bones, to go above the ankle and amputate the leg, claiming that better functional results follow this operation. We do not consider this opinion a sound one, and think that those surgeons who have had large experience with partial amputations of the foot are convinced that these are better procedures, as shown by the excellent results that follow these operations. In amputating through the foot it has also been advised by Hancock to consider the foot as composed of one bone, and, after having made sufficient flaps, to saw through the bones of the foot, disregarding the articulations. Where it is possible, however, we are inclined to think that the systematic operations through the articulations are better operations, although almost every surgeon has found in actual work that some of these procedures have to be modified by sawing the bones at certain points. In all amputations of the foot involving the tarsus the surgeon should be thoroughly familiar with the anatomy of the foot and the surgical landmarks of the different articulations. (Fig. 227.) We refer to those laid down by Bryant, which are as follows: On the inner side of the foot, not far from the inner malleolus, the tubercle of the scaphoid bone is to be felt (*A*) as a marked prominence. About half an inch in front of this will be found the articulation with the cuneiform bone (*B*), and one inch in front of this the joint which the surgeon will have to open in Lisfranc's or Hey's operation (*C*). Just above the tubercle of the scaphoid will be found the articulation with the astragalus, the line of Chopart's amputation (*D*). On the outer side of the foot, one inch below the external malleolus, a sharply defined projection will be felt, which is the peroneal tubercle (*E*); half an inch in front of this will be found the joint which separates the os calcis from the cuboid (*F*), this joint forming the outer circle of Chopart's amputation. Half an inch in front, or one inch from the tubercle, the prominence of the fifth metatarsal bone is to

Fig. 227.



Surgical landmarks to the articulations of the foot. (Bryant.)

be felt (*H*), a line above this prominence indicating the articulation of the cuboid bone, which forms the outer boundary for Hey's or Lisfranc's amputation.

Hemorrhage during tarso-metatarsal or tarsal amputations is controlled by the application of a tourniquet to the femoral artery, or, better, by the application of Esmarch's elastic strap to the fleshy part of the leg.

Tarso-Metatarsal Amputation (Lisfranc's).—The incision for this amputation is a curved one, carried across the dorsum of the foot, from the base of the fifth to the base of the first metatarsal bone. The incision should involve the skin only, its centre lying half an inch or more below the centre of the line of the articulations, and it should begin and end at the sides of the foot at their junction with the sole. A plantar flap should be marked out by a curved incision crossing the sole of the foot near the articulations of the toes with the metatarsal bones, starting and ending at the same points as the dorsal incision. Having cut the dorsal flap as above described, it should be dissected back to the line of the articulations; the tendons, muscular fibres, and fascia being divided, the joints between the tarsal and the metatarsal bones are next opened with a stout, narrow-bladed knife. Difficulty is sometimes experienced in opening the joint between the head of the second metatarsal bone and the second cuneiform bone, which occupies a position higher in the foot than the other articulations. The disarticulation may be facilitated by forcibly depressing the anterior portion of the foot. After all the joints have been opened, the plantar ligaments are divided, the knife is passed behind the ends of the metatarsal bones, and a plantar flap is cut from within outward, following the line of the incision previously marked out. (Fig. 228.) The plantar flap may be cut from without inward if preferred. The vessels requiring ligatures are the dorsal and interosseous arteries and the plantar branch of the dorsalis pedis; in the plantar flap the plantar digital branches of the external plantar, as well as the internal plantar artery, usually require the application of ligatures. Care should be taken that the dorsal incision is not carried too far back, or the joint between the scaphoid and cuneiform bones may be opened on the inner margin of the foot. The stump resulting from this amputation is a well-shaped and very useful one. (Fig. 229.)

Fig. 228.

Lisfranc's amputation of the foot.

Fig. 229.

Stump after Lisfranc's amputation. (Agnew.)

Tarso-Metatarsal Amputation (Hey's).—In this amputation a curved incision is made from the base of the fifth metatarsal bone, across the dorsum of the foot, to the base of the first metatarsal bone. The line of incision and the steps of the amputation are similar to those in Lisfranc's amputation, with the exception that the projecting portion of the

internal cuneiform bone is sawed off after disarticulating the metatarsal bones. This modification, although it improves the appearance of the stump, possesses no other advantage.

Medio-Tarsal, or Chopart's Amputation.—In this amputation the whole of the tarsus except the astragalus and the calcaneum is removed, the disarticulation being through the joints formed by the astragalus and os calcis behind and the scaphoid and cuboid in front. In performing Chopart's amputation an incision is made from the tubercle of the scaphoid bone across the dorsum of the foot, an inch in front of the head of the astragalus, to the lower and outer border of the cuboid bone. A plantar flap is next marked out by an incision beginning and ending at the same points as the first incision and crossing the sole of the foot four or five finger-breadths nearer the toes; the dorsal flap is next dissected up, and after the tendons and fascia and ligaments have been divided the joint is opened. The disarticulation may be much facilitated by forcibly bending the foot downward, so as to make the anterior ligaments of the joint tense. The plantar flap is next cut from within outward, following the line of the previously marked-out plantar incision. (Fig. 230.) If, on adjusting the flaps, it is found that any tension is present from the drawing up of the heel by the tendo Achillis, this tendon should be divided. The stump resulting from Chopart's amputation is often a very useful one, but in some cases the subsequent retraction of the heel by the action of the muscles inserted through the tendo Achillis causes pressure upon the cicatrix, which interferes with the use of the stump. In these cases division of the tendo Achillis may be of service. To prevent this complication, the extensor tendons may be sutured to the face of the stump at the time of operation.

FIG. 230.

Chopart's amputation of the foot. (Bryant.)

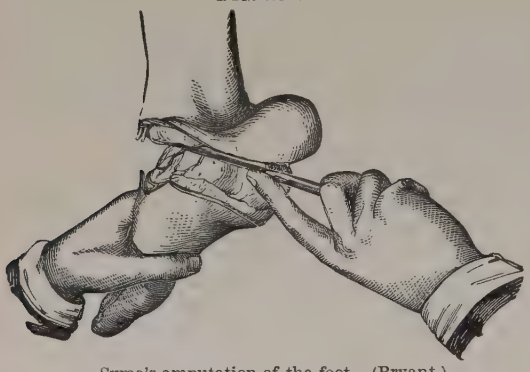
Subastragaloid Amputation.—In this operation all the bones of the foot are removed except the astragalus. In performing this amputation an incision is made beginning an inch below the tip of the external malleolus, and is carried forward to the base of the fifth metatarsal bone; then carried across the dorsum of the foot to the calcaneo-cuboid articulation, on a line with which a transverse incision is made through the tissues of the sole of the foot. The joints between the scaphoid bone and the astragalus, and between the astragalus and the os calcis, are opened, and the os calcis is carefully dissected out, the point of the knife being kept close to the bone during dissection to avoid injury of the vessels; the ligaments are divided, and the astragalus only is allowed to remain in place.

Tripier has modified the subastragaloid amputation by leaving the upper part of the calcaneum, which he saws through on an angle with the sustentaculum tali and at right angles to the axis of the leg. The incisions are the same as in Chopart's amputation.

AMPUTATIONS AT THE ANKLE-JOINT.

Syme's Amputation.—In performing this amputation the foot should be at a right angle to the leg, and an incision should be made from the centre of one malleolus, directly across the sole of the foot, to the centre of the opposite malleolus; the tissues of the heel are next carefully dissected from the bone by keeping the knife close to the osseous surface until the tuber-

Fig. 231.



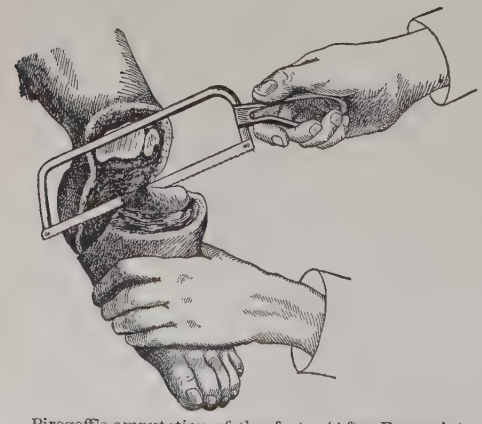
Syme's amputation of the foot. (Bryant.)

Fig. 232.

Stump after Syme's amputation. (Agnew.)

osity of the os calcis is fairly turned. (Fig. 231.) The two extremities of the first incision are then joined by a transverse one across the instep, and, the joint being opened, the lateral ligaments are divided to complete the disarticulation; the knife is next used to clear the malleoli, and these with the articulating surface of the tibia are removed with a saw. In dissecting out the os calcis and making the heel-flap, great care should be taken to keep close to the bone, so as not to destroy the vascular connections of the flap. The stump resulting from this amputation is an excellent one, and is often useful without an artificial limb. (Fig. 232.)

Fig. 233.

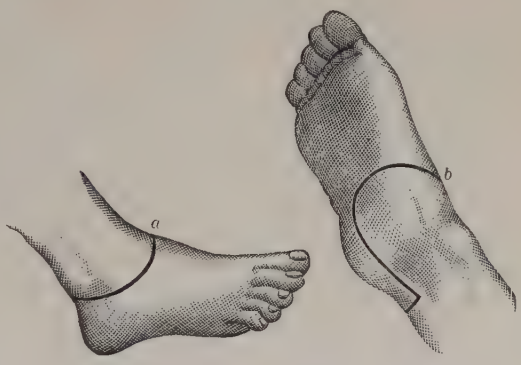


Pirogoff's amputation of the foot. (After Esmarch.)

Pirogoff's Amputation.—In this amputation all the tarsal bones are removed except the posterior portion of the os calcis. In performing Pirogoff's amputation an incision is carried from the tip of the inner malleolus, over the instep, half an inch in front of the anterior edge of the tibia to a point half an inch in front of the tip of the outer malleolus. A second incision crossing the sole of the foot and carried down to the bone, uniting the extremities of the first incision, is next made. The plantar flap thus made is dissected back for a quarter of an inch, the joint being opened by dividing the lateral ligaments, the astragalus is disarticulated, and

the malleoli are exposed. A narrow saw is next applied to the upper and posterior part of the calcaneum behind the astragalus, and it is divided obliquely downward in the line of the plantar incision. (Fig. 233.) The malleoli and a thin slice of the tibia are next removed with a saw, as in Syme's amputation. Some surgeons do not remove the malleoli, but press the sawed surface of the os calcis between them when it is possible to do so. By this amputation an admirable stump may be obtained; the calcaneum being firmly attached to the bones of the leg, the length of the limb is not seriously altered.

Fig. 234.



Line of incisions in Roux's amputation at the ankle: *a*, dorsal, *b*, plantar, incision.

Roux's Amputation at the Ankle-Joint.—In this method of amputation an incision is made at the outer edge of the tendo Achillis a little above its insertion, and is carried forward under the outer malleolus and across the instep and back to a point just in front of the inner malleolus; the incision is carried from this point downward and partly across the sole of the foot, and then back to the point of origin of the original incision. (Fig. 234.) The flaps are dissected up for a short distance; the ankle-joint is then opened, the disarticulation is effected, and the internal flap is carefully dissected from the bones.

Fig. 235.

Result of osteoplastic resection of the foot. (After Esmarch.)

Osteoplastic Resection of the Foot.—As a substitute for amputation at the ankle-joint in injuries or diseases of the os calcis or in intractable ulceration of the heel, the Mikulicz-Wladimiroff operation, or osteoplastic resection of the foot, has been practised, consisting in the removal of the soft parts covering the heel, together with the os calcis and the astragalus, and bringing into contact the sawn surfaces of the tibia and fibula on the one hand and those of the cuboid and scaphoid on the other, the foot thus being fixed in the position of talipes equinus, and the patient walking on the balls and phalanges of the toes. (Fig. 235.) A transverse incision is made across the sole of the foot from the tuberosity of the scaphoid to a point a little behind the fifth metatarsal bone; two incisions are next carried from the extremities of this cut on each side of the foot obliquely upward to the bases of the malleoli; the two extremities of the cut are finally joined by a horizontal incision which crosses over the tendo Achillis and completes the wound. The foot is next flexed, the tendo Achillis is divided, and the ankle-joint is opened from

behind. The soft parts upon the dorsum of the foot are next separated from the astragalus by an elevator; the calcaneo-cuboid and astragalo-scaphoid joints are then opened from above, and the whole of the heel, together with the os calcis and the astragalus, is removed; the lower ends of the tibia and fibula and the joint surfaces of the scaphoid and cuboid are next removed with a saw. The cut surfaces of the bone are then brought together and held in contact by sutures; a gauze dressing is applied, and over this a plaster of Paris dressing, including the foot and leg. The patient after the wound is healed is usually compelled to wear a specially constructed shoe. As the result of this operation the limb is sometimes a little lengthened, so that it becomes necessary to wear a high shoe upon the sound foot to equalize the length of the limbs.

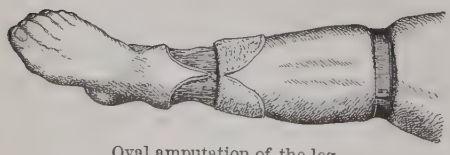
AMPUTATIONS OF THE LEG.

The leg may be amputated in its lower, middle, or upper third, the rule being to save as much of the limb as possible, but as regards the application of artificial limbs we think the stumps resulting from amputation in the middle and upper thirds will be found more satisfactory than those from amputation just above the ankle. In sawing the bones it is of advantage to divide the fibula at a slightly higher point than the tibia. The leg may be amputated by the circular, modified circular, oval, or elliptical method, the long anterior rectangular flap method (Teale), or the external flap method (Sédillot). The choice of method will depend somewhat upon the portion of the leg at which the amputation is to be performed. In the lower third of the leg the circular or modified circular method is usually employed. In the middle and upper third the elliptical method or that of Sédillot may be employed with advantage. Hemorrhage is controlled during the operation in amputations of the leg by applying the tourniquet or elastic strap to the femoral artery in Scarpa's triangle or just above or below the knee.

Circular Method.—In amputating the leg in the lower third a circular incision is made through the skin and connective tissue just above the malleoli, and a cuff is dissected up for a sufficient distance; a circular incision of the tendons and muscles is next made, dividing all the tissues down to the bone. The interosseous membrane is next divided with a narrow knife, a retractor is applied to hold back the soft parts, and the bones are divided with a saw.

The Modified Circular or Oval Method.—In this method of amputation of the leg two oval flaps of skin and connective tissue are made, either antero-posterior or lateral; these are dissected up. A circular division of the muscles is next made down to the bone, the interosseous membrane is divided, and, the soft parts being held out of the way by a retractor, the bones are divided with a saw. (Fig. 236.)

Fig. 236.

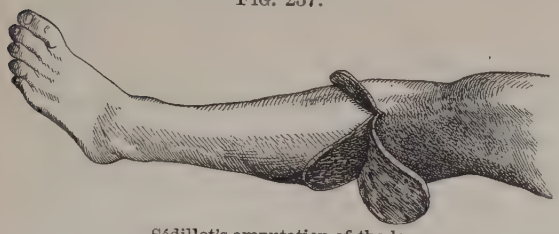


Oval amputation of the leg.

Sédillot's, or External Flap Method.—In this method of amputation of the leg the point of the knife is entered a finger-breadth external

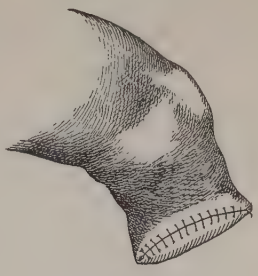
to the spine of the tibia and carried outward grazing the fibula, and is brought out as far as possible to the outer side. A flap three or four inches in length is then cut from within outward. The extremities of the incision are next united by an incision across the inner side of the limb involving the skin and fascia only, and any remaining muscular tissue is divided and the bones are sawed. (Fig. 237.) The long external flap is then brought over the ends of the bones and fastened to the edges of the incision on the inner side of the limb. Ashhurst modifies this operation by cutting the long external flap from without inward, and makes also a short internal flap in the same manner. By either method the resulting stump is a good one, with the ends of the bones covered by the tissues of the external flap. (Fig. 238.)

Fig. 237.



Sédillot's amputation of the leg.

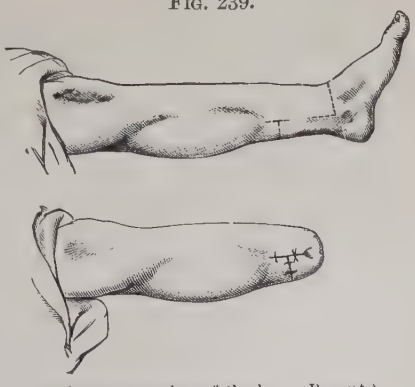
Fig. 238.



Stump after Sédillot's amputation. (After Esmarch.)

Long Anterior Rectangular Flap Method (Teale).—In this method of amputation of the leg an incision equal in length to one-half of the circumference of the leg is made from the point at which the bones are to be divided, on one side of the leg, and is carried across the limb and back upon the other side to a point opposite the point of starting. The flap thus marked out is dissected up to its base, and a posterior flap of one-quarter the length is next cut by a transverse incision down to the bone, and is dissected back to the line of origin of the first incision. The bones are divided with a saw, and the long flap is next doubled back and its edges secured to the posterior flap. (Fig. 239.) The long flap may be cut from the posterior surface of the leg and the short flap from the anterior surface.

Fig. 239.



Teale's amputation of the leg. (Bryant.)

The vessels which require ligature in amputations of the leg are the anterior and posterior tibial and the peroneal and muscular branches. Care should be taken to make the flaps sufficiently long, so that the anterior flap shall not be tightly drawn over the spine of the tibia. Formerly, when suppuration was common after amputations, the spine of the tibia often came through the anterior flap, and a limited necrosis of this portion of the bone was apt to occur. To avoid this trouble it

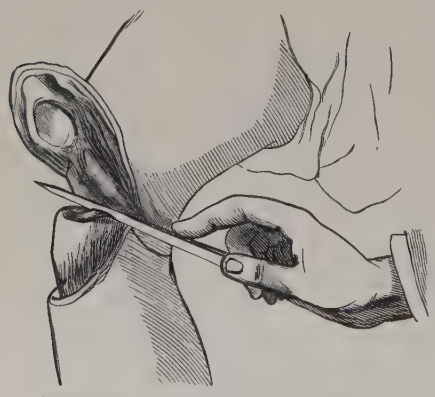
was recommended that the anterior edge of the spine of the tibia be sawed off obliquely. This procedure is now rarely practised. Before dividing the bones it is often possible in amputations of the leg, especially in young subjects, to turn up a periosteal flap from the tibia. Before closing the stump this periosteal flap may be stitched over the sawed surface of the bone. In dressing a case of amputation of the leg, after the vessels have been secured a drainage-tube is introduced, and the muscular tissues in many cases may be brought together by buried sutures of catgut, the skin-flaps being next approximated by another layer of sutures. A copious gauze dressing is then applied, and held in position by the turns of a bandage.

AMPUTATIONS AT THE KNEE-JOINT.

Amputations at the knee-joint may be done by the anterior flap method, or by the elliptical or the circular method, and the bones may be disarticulated or a section may be made through the condyles of the femur.

Anterior Flap Method.—In amputating at the knee-joint by this method a long anterior cutaneous flap is formed: the incision, beginning half an inch below the internal condyle of the femur, is carried down the leg for five inches, then crosses the anterior surface of the leg to a corresponding point on the opposite side, and is carried back to a point half an inch below the external condyle of the femur. This flap is dissected up and the ligament of the patella is divided; the joint is then opened, the lateral ligaments are divided, and the disarticulation is effected. A short posterior flap is next cut by transfixion, or from without inward. The semilunar cartilages and the patella are not removed. (Fig. 240.)

Fig. 240.



Amputation at the knee by an anterior flap. (Agnew.)

Elliptical or Oval Method.—In the elliptical method an incision crossing the spine of the tibia five finger-breadths below the lower extremity of the patella is carried around the back of the leg three finger-breadths higher than in front; the tissues in the front of the leg are dissected up until the tendon of the patella is exposed; the leg is then flexed and the ligament of the patella is divided; the capsular ligament and the lateral and crucial ligaments are next severed, care being taken not to injure the popliteal vessels with the point of the knife. The tibia is next drawn forward, the knife is passed behind its posterior border, and the remaining soft parts are divided from within outward.

Circular Method.—In performing this amputation at the knee-joint, the leg should be extended, and a circular incision should be made around the leg three inches below the patella, dividing the skin and connective tissue. The skin is next dissected up, on all sides, as far as the lower edge of the patella; the cuff of skin being turned back at this point, the knee is

flexed, the ligamentum patellæ is cut through, the joint is opened, and the disarticulation is effected by dividing the capsular and lateral ligaments close to the femur, so that the semilunar cartilages and the greater part of the capsular ligament shall remain attached to the tibia. The crucial ligaments and remaining tissues are then divided, and the disarticulation is effected. After the vessels have been ligatured, the cuff of skin is turned down over the patella and cartilages, and its edges are brought together transversely by sutures.

Gritti's Amputation at the Knee-Joint.—In this operation a long anterior rectangular flap is cut and dissected up, and after the disarticulation has been effected the skin covering the posterior surface of the knee is cut from within outward. The condyles of the femur are next removed by a saw, just above the edge of the articular cartilage, and the articular surface of the patella is also removed with the saw. The patella is next brought down so that its sawed surface shall be in contact with the sawed surface of the condyles, and the flaps are approximated with sutures.

Carden's Amputation.—This amputation is performed by making an anterior flap whose lower extremity is three finger-breadths below the patella; this is cut and dissected up, and the disarticulation is effected. A short posterior flap similar to that in amputation through the knee-joint is next cut; the joint is opened, and the disarticulation is effected. The patella is then removed and the condyles of the femur are sawed through just above the edge of the articular cartilage.

The vessels requiring ligature in amputations at the knee-joint are the popliteal artery and popliteal vein, the sural arteries, and a few muscular branches. The circular or long anterior flap method is generally employed in amputation at the knee.

AMPUTATIONS OF THE THIGH.

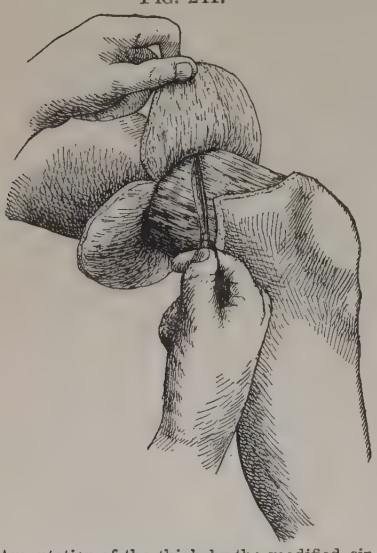
Amputation may be performed at any portion of the thigh; the gravity of the operation increases with the proximity of the section to the trunk. The methods employed in amputation of the thigh are the circular method, the modified circular method with oval skin-flaps, and the method by transfixion.

The Circular Method.—This method of amputation is employed at the lower portion of the thigh and in cases where the thigh is not very muscular. In this method a circular incision is made around the thigh, dividing the skin and cellular tissue; this having been dissected back for a short distance and retracted, the surgeon makes a circular sweep with the knife, dividing all the tissues down to the bone; a retractor is next applied, and the bone is divided with a saw.

The Modified Circular Method.—This method of amputation is applicable to all portions of the thigh, and consists in making anterior and posterior oval skin-flaps or lateral oval flaps (Fig. 241); these are dissected up, and a circular incision of the muscles down to the bone is next made. The soft parts being retracted, the bone is divided with a saw.

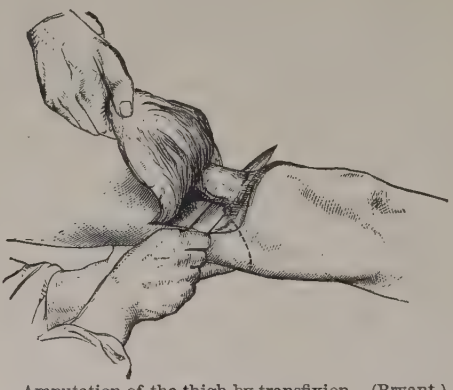
Method by Transfixion.—Amputation of the thigh by transfixion is not much practised at the present time, but was formerly a popular operation on account of the rapidity with which it could be performed. In this method of amputating a long knife was entered at the outer portion of the thigh, carried over the femur, and brought out at a corresponding point on the inner portion of the thigh; a flap of sufficient length was then cut by carrying the knife downward and bringing it out to the surface of the skin (Fig. 242); the knife was then entered behind the

Fig. 241.



Amputation of the thigh by the modified circular method.

Fig. 242.



Amputation of the thigh by transfixion. (Bryant.)

bone at the same point, and a posterior flap was cut from within outward. In amputations of the thigh the femoral artery and femoral vein require the application of ligatures; also, in high amputations, the profunda or branches of the profunda, and numerous muscular branches.

AMPUTATION AT THE HIP-JOINT.

The gravity of this operation depends largely upon the amount of blood that is lost during the procedure, and various methods of controlling bleeding have therefore been devised. Hemorrhage during hip-joint amputations was formerly controlled by digital pressure upon the artery, by the use of the abdominal tourniquet, or by Davy's lever, which made compression on the aorta or iliac artery through the rectum, or by compression of the abdominal aorta by the hand by Macewen's method. Esmarch's elastic strap has also been employed during amputations at the hip-joint, the strap being applied in such a manner that it occupies the position of a spica bandage of the groin. The method devised by Wyeth of controlling hemorrhage during amputations at the hip-joint is described later. Jordan and Senn have employed a method of amputating at the hip-joint, in which the head of the bone is first disarticulated through the external incision, and the bleeding is controlled before the amputation is completed by passing an elastic strap or tube around the soft parts above the point where

they are to be divided. Numerous methods of amputation of the hip-joint have been devised, but those principally employed are the oval method, the antero-posterior flap and circular method. In any of these methods the hemorrhage during the operation may be controlled by the use of Wyeth's pins and the elastic strap.

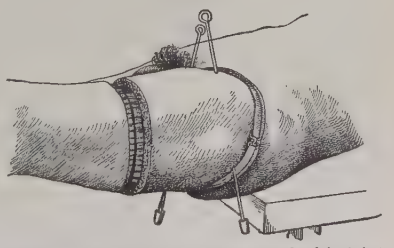
Oval Method.—In this method of amputation the point of a strong knife is passed into the tissues below the anterior superior spinous process of the ilium, and two oblique incisions are made, one forward and downward, the other backward, both incisions meeting on a transverse line on the inner side of the thigh. The muscles are next divided on a little higher line, and when the joint is exposed disarticulation is effected from the outer side, and any remaining tissue is divided.

Antero-Posterior Flap Method.—In this method of amputation at the hip the point of a long amputating knife is thrust into the tissues about two finger-breadths below the anterior superior spinous process of the ilium, is pushed through the tissues, grazing the hip-joint, and is then brought out at the opposite side of the thigh close to the junction of the scrotum with the thigh. The knife is next carried downward close to the bone, and an anterior flap of sufficient length is cut from within outward; this flap being held back by an assistant, the head of the bone is disarticulated, and, the knife being passed behind the bone, the posterior flap of equal length is cut from within outward.

Guthrie's Method of amputation at the hip-joint is also an antero-posterior flap method, and consists in cutting the flaps from without inward, a smaller knife being used for this purpose, and the posterior flap being cut first.

Wyeth's Method of Controlling Hemorrhage during Amputation at the Hip-Joint.—This method is now very generally employed, and its adoption has diminished in a remarkable degree the mortality following amputations at the hip-joint. In Wyeth's method, the patient is brought well over the edge of the table, and an Esmarch bandage is applied to the limb up to the crotch. Two stout steel mattress-needles, or steel skewers, about twelve or fourteen inches in length, are required; the point of one of these needles is passed through the skin one and a half inches below and slightly to the inner side of the anterior superior spine of the ilium, and carried through the tissues about half-way between the great trochanter and the spine of the ilium, external to the neck of the femur, its point being made to emerge just behind the trochanter; the second needle is made to enter the skin an inch below the crotch, internal to the saphenous opening, and its point is made to emerge about an inch and a half in front of the tuber ischii. The points of the needles are next protected with corks, and a long piece of rubber tubing or an Esmarch elastic strap is wound tightly five or six times around the limb above the fixation needles. (Fig. 243.)

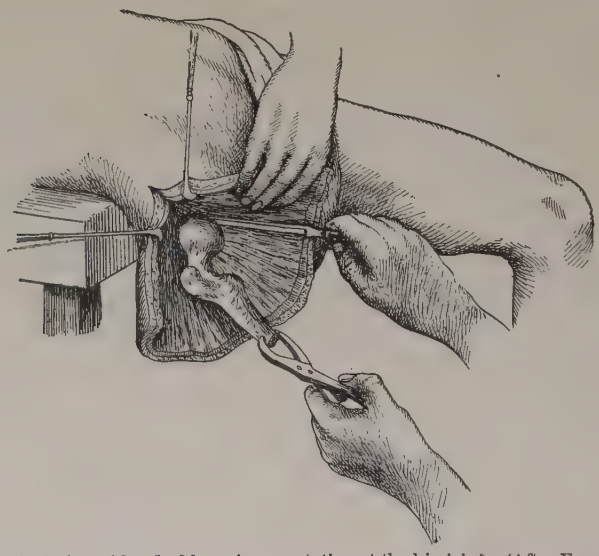
Fig. 243.



Wyeth's method of amputating at the hip-joint.

The Esmarch bandage is then removed, and a circular incision of the skin and cellular tissue made five inches below the constricting band; this cuff of skin and cellular tissue should be dissected up to the level of the lesser trochanter; a circular division of all the muscles should next be made at

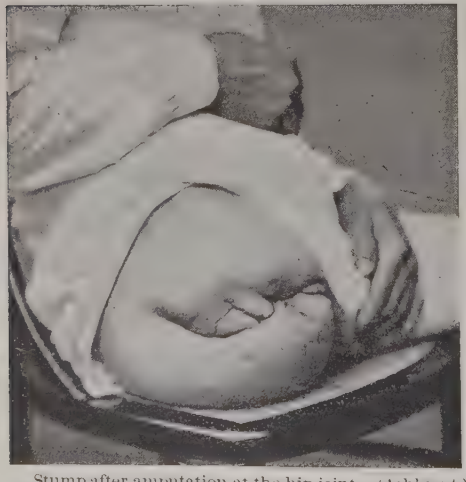
Fig. 244.



Disarticulation of head of bone in amputation at the hip-joint. (After Esmarch.)

this point, and the bone should be divided with a saw. The femoral artery and femoral vein, the profunda, and any large muscular branches should now be seized with hæmostatic forceps and ligated. After all vessels which can be located have been ligated, the rubber tube is removed, and any vessels which bleed should be grasped with hæmostatic forceps and secured. The sawn surface of the femur is next seized with bone forceps, and an incision is made upon the outer side through the muscles until the neck and head of the bone are exposed, when the disarticulation should be accomplished. (Fig. 244.) Wyeth now practises disarticulation of the head of the femur without sawing the bone. A drainage-tube is introduced, and the edges of the flaps are brought together vertically. The appearance of the stump resulting from amputation at the hip-joint is shown in Fig. 245.

Fig. 245.



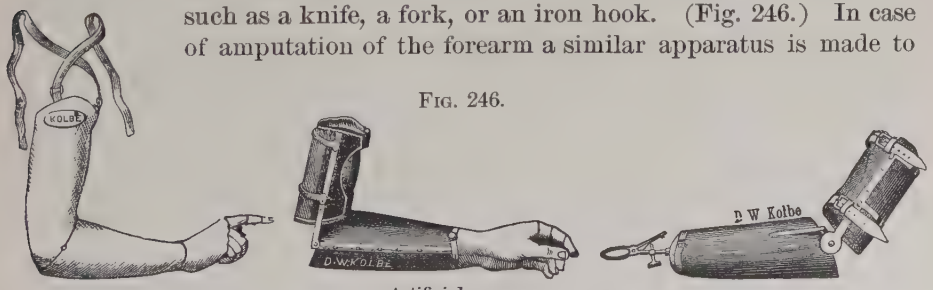
Stump after amputation at the hip-joint. (Ashhurst.)

PROSTHETIC APPARATUS AFTER AMPUTATIONS.

In performing amputations the surgeon should bear in mind the possibility of the patient's wearing an artificial limb, and for this reason should plan the operation in such a way that a useful stump may result, and should also endeavor to save as much of the limb as possible. This is particularly important in amputations of the thigh, where the longer the stump is the more satisfactory it will be for the adaptation of an artificial limb. In the leg, an amputation in the upper or middle third is better suited for the adaptation of prosthetic apparatus than one in the lower third; indeed, the makers of artificial limbs hold that a stump not longer than half the length of the leg gives better results with prosthetic apparatus than a long stump extending into the lower third of the leg. The fact that partial amputations of the foot—Chopart's, Pirogoff's—are often difficult to fit with prosthetic apparatus has influenced many surgeons to recommend amputation of the leg in these cases rather than partial amputation of the foot. But it should be borne in mind that many cases of partial amputation of the foot can go about comfortably without any apparatus other than a specially constructed leather shoe, or one with a steel plate in the sole and narrow steel braces fastened to the leg by a flexible collar. Prosthetic apparatus of the upper extremity, except in cases of amputation below the elbow, is usually of little practical value, and is serviceable only for cosmetic purposes. Many patients who have lost a limb never wear any prosthetic apparatus, by reason of the expense of the appliance and the discomfort which it sometimes entails until the wearer becomes accustomed to its use.

Artificial Arms.—The artificial arm which is generally adapted to amputations below the shoulder consists of a closely fitting leather socket, which covers the stump for several inches, and is secured to it and the body by straps. Light internal and external steel rods jointed at the elbow and containing a cogged wheel and ratchet, which allow flexion and extension at the elbow with fixation at any angle, are attached to this and secured to a wooden block below the elbow, and at the end of this is fastened an artificial hand to which various implements may be screwed, such as a knife, a fork, or an iron hook. (Fig. 246.) In case of amputation of the forearm a similar apparatus is made to

FIG. 246.



Artificial arms.

fit a portion of the stump of the forearm, and is secured to the arm above by a laced band. Many complicated forms of artificial arms have been devised which allow flexion and extension of the fingers through cords worked by movements of the opposite arm.

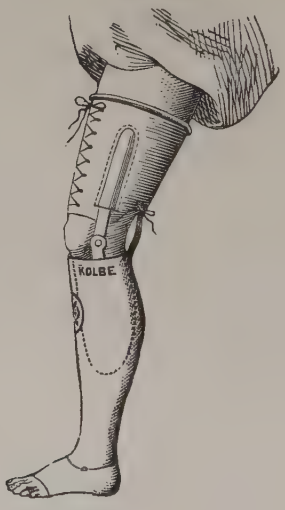
Artificial Legs.—In cases of partial amputations of the foot a shoe with a metal sole and narrow steel bands secured to the leg, and with a wooden block filling up the anterior portion of the shoe, corresponding to the portion of the foot removed, will constitute a satisfactory apparatus. In amputations of the leg a more complicated form of prosthetic apparatus is required.

In amputations at the knee-joint or through the upper part of the leg, the cheapest form of artificial apparatus which is employed is known as the "peg leg," or poor man's leg, which consists of a stout wooden stick, with an expanded upper extremity or socket composed of a conical piece of light wood, with two lateral splints embracing the thigh, the inner splint extending only to the middle of the thigh, while the external one reaches to the

Fig. 247.

Peg leg.

Fig. 248.



Artificial leg.

pelvis and is fastened by a padded pelvic belt; a strap passing around the lower part of the thigh holds the inner splint to the outer one. (Fig. 247.) The front of the flexed knee rests upon a cushion between the two splints. In adapting an artificial limb in a case of amputation of the leg it is important that no pressure be brought upon the surface of the stump, and that the weight of the body be supported by the thigh, the circumference of the leg, the inner border of the patella, the tuberosities of the tibia, and the tuberosities of the ischium. Many very ingenious forms of artificial legs have been manufactured which allow a certain amount of movement at the ankle and flexion and extension at the knee-joint. (Fig. 248.) No satisfactory artificial apparatus can be adapted in cases of amputation at the hip-joint.

CHAPTER XIV.

SURGICAL DISEASES OF THE SKIN.

CERTAIN affections of the skin present themselves to the surgeon, either independently or as complications of surgical conditions, and they will be briefly described. The various pathological lesions which occur in the skin are given special names. **Erythema** is a more or less extensive spot or patch of redness in the skin, in which the redness disappears on pressure. A **macule** is a spot or patch of dark color which does not disappear on pressure, being due to hemorrhage or pigment. A **petechial** spot is a minute red point, which looks like a flea-bite. A **papule** is an elevation of the skin, flat or acuminated, without any free fluid or pus. A **wheal** is a large papule. A rather thick, large papule is called a **tubercle**, but this term is misleading on account of its common association with tuberculosis, with which these lesions have no necessary connection, and it would be better to use the word **nodule** instead of tubercle to designate them. A **vesicle** is an accumulation of serum beneath the epidermis, commonly known as a blister, and called a **bulla** when very large. A **pustule** is a small collection of pus in the skin or simply beneath the epidermis. We have already described furuncle and carbuncle in speaking of cellulitis.

Dermatitis is an inflammation of the skin from any cause. It may be acute or chronic, and exists in all grades, from mere congestion of the surface to vesiculation, pustulation, general suppuration, and sloughing. Fibrinous false membranes may be formed. Dermatitis is usually seen in surgical cases as the result of irritating dressings or discharges, or is produced intentionally for counter-irritation. In all surgical measures, particularly in these days of vigorous antisepsis, it is well to emphasize the necessity for avoiding the production of dermatitis, for the condition will be a serious drawback to the comfort of the patient, and it may jeopardize the aseptic course of the wound by the serous discharge from the skin. Dermatitis generally subsides, sometimes being followed by desquamation of the epidermis; but occasionally an obstinate eczema may be set up.

Treatment.—The milder forms are to be treated by wet dressings of mild solutions or plain sterilized water, or by ointments of boric acid or zinc oxide, or by simply powdering the skin with bismuth, chalk, lycopodium, calomel, or zinc oxide. The application of ointments or powder will protect the skin from irritation by wound discharges, feces, or urine, and prevent dermatitis. The same precaution may be employed on the surrounding skin when it is necessary to apply very strong antiseptics.

The dermatitis due to the *poison ivy* (Rhus toxicodendron) is worthy of note, as it might possibly be confounded with erysipelas, although the char-

acteristic location of the eruption, beginning between the fingers, the trifling constitutional reaction, and the intense itching make the diagnosis easy in well-marked cases. The eruption is at first a mere erythema, but vesicles soon appear, accompanied by considerable subcutaneous and cutaneous œdema, enough in some cases to close the eyes and distort the genitals. The disease is self-limited, running its course in a week, although sometimes prolonged by relapses. It should be treated on the same principles as an acute eczema, which, indeed, occasionally follows it. Sulphate of zinc, gr. ij; water, ʒi; or extr. grindelia robusta, fʒi to fʒiv; water, Oi, may be used as a wet application. An ointment of carbolic acid (gr. x–xx to ʒi) or ichthyol (ten per cent.) will soothe the itching. We have had excellent results from the latter, applied to the face on a mask.

Eczema occurs in two forms, the acute and the chronic. In the *acute* variety the affected part is reddened and covered with minute vesicles, which may break and form crusts, and the surface of the skin may desquamate, leaving a raw-looking, deep-red patch, secreting an abundant sticky serous discharge. Papules and even pustules are sometimes seen, and the skin is always thickened. While the disease undoubtedly depends largely upon some constitutional disturbance, such as gout, it may be excited by many irritating local applications, and often it starts from such an irritated spot and slowly spreads all over the body, resembling the spread of erysipelas, but not being quite so continuous in its advance, for in some cases it seems as if the poison were absorbed by the blood and showed itself by cutaneous irritation in different parts, while in others it appears as if it were carried to other parts by the fingers after scratching some vesicles at the place first affected. The itching is intense, and often causes great suffering.

Treatment.—We have found a weak solution of bicarbonate of sodium to be the best means of allaying the itching, ointment being badly borne. A solution of zinc sulphate, gr. xv–xxx to ʒi, is also recommended. The first necessity is to discontinue the irritating dressing which has caused the eruption. It is well to give a purge, and alkalies internally. When anæmia coexists, a combination of magnesiæ sulphat., ʒi; ferri sulphat., gr. i; acidi sulphurici dil., ♏viii; aquæ, q. s. ad ℥ss, given in water before breakfast, is excellent as a tonic aperient.

Chronic eczema is marked by great thickening of the skin, with the formation of crusts and scales, which, when peeled off, leave a red, "weeping" surface behind them. Its **treatment** is very difficult, requiring general constitutional remedies and local applications of a stimulating nature, such as tar, green soap, and caustic potash. Very great judgment is necessary in the employment of these powerful agents, for if applied too strong the reaction may be too intense and the disease rendered worse. A soothing ointment, such as oxide of zinc, should first be applied, and a tenth part of unguentum picis liquidæ can be added to it at subsequent dressings, gradually increasing the amount of the tar until a proper strength is reached. Oil of cade is identical in its effects, and may be employed in ointment or with alcohol, oil of almond, or glycerin, especially for the scalp. Green soap and potash are employed in the very dry, chronic, scaling variety of eczema, especially of the palms of the hands. Lassar recommends surgeons

who are annoyed by eczema of the hands caused by vigorous disinfection to apply some oily material after washing, such as equal parts of olive oil, glycerin, lanolin, and vaseline, with resorcin, gr. x, added to each ounce of the mixture.

Diseases of the Sebaceous Glands.—A functional disturbance with alteration of their secretion causes the production of the so-called blackheads or **comedones**, which are nothing more than inspissated secretion collected in the ducts and mixed with dirt. If neglected, they become infected, and suppuration ensues.

Acne is an eruption of pustules from suppurative inflammation of the sebaceous glands. The treatment of acne must be both local and general. The comedones should be squeezed out with a watch-key or similar instrument. Pustules must be opened with a sharp-pointed knife. The skin should be thoroughly washed with hot water and soap two or three times a day, followed by vigorous rubbing with a flannel cloth, and anointing with boric acid ointment well rubbed in, these measures stimulating the glands to activity and producing a healthy secretion. The general health requires attention; out-door exercise is to be enforced, tonics and laxatives ordered, and any derangements of the sexual organs, such as are so often seen associated with this affection, which is very common about puberty, are to be corrected. When the secretion of the sebaceous glands collects in minute ducts which are entirely closed by epidermis, the condition known as **milium** is produced, consisting of minute, rounded, white elevations beneath the superficial epidermis. A discharge of thickened sebaceous matter from the glands with a tendency to form scales on the surface is known as **seborrhœa**, a condition frequent in the scalp, producing dandruff, and resulting in early falling of the hair, and also seen in limited patches on the face, especially about the nose and the eyes. In the latter situation the affection is of great importance, as it is common in persons past middle life, and is apt to result in the development of epithelioma of the skin. This condition can be distinguished from localized patches of eczema by the ease with which the crust is detached from the skin, the peculiar soft cheesy character of the crust, and the less irritated appearance of the underlying skin. When **treatment** is undertaken early, good results can be obtained, the best means being washing with hot water and mild soap, and inunctions of boric acid or resorcin ointments (ten per cent.), but without hard rubbing, for fear of increasing the inflammatory condition of the glands and precipitating the development of epithelioma.

Lupus vulgaris is a disease of the skin and mucous membranes caused by the bacillus tuberculosis, and marked by the formation of rather soft, dark red nodules, with a tendency to ulceration. It appears sometimes in a single patch, which may spread evenly or in a serpiginous form, or in scattered patches, which later coalesce. Occasionally hypertrophic forms are found, with the formation of warty growths of considerable size. Lupus is most common on the face and extremities, although it may occur elsewhere. Its course is exceedingly slow and obstinate, spontaneous healing being a rarity, although cicatrization may take place at one edge while the disease is advancing at another. The ulceration may be so extensive as to

destroy the entire nose, eyelid, or lip, and if the process be arrested the resulting cicatrization only adds to the disfigurement. In the neighborhood of the eye ectropion is a common result of these contractions. It is often complicated with tuberculosis of other organs, such as the lymph-nodes, bones, joints, and lungs. The disease begins in childhood.

Diagnosis.—The diagnosis is made by the soft granulation-tissue which forms the masses, the formation of new foci in the neighborhood of old ones, the appearance of the new foci as small yellow-brown spots easily penetrated by a blunt instrument, and the characteristic scarring. In chronic eczema, on the other hand, the skin is hard and not ulcerated. In acne rosacea the nodules formed on the nose may resemble lupus, but the skin is bright red and hard, and suppuration is common. It is most difficult to distinguish lupus from epithelioma or syphilis. For the peculiarities of the last we refer to its own chapter. Epithelioma is usually recognizable by the firmness of the tumors, their pearly translucency, the greater thickness of the lesions (except in rodent ulcer), the beginning of the disease late in life, and the more marked sensations of prickling, crawling, etc. It must be borne in mind that epithelioma often develops upon old lupous ulcerations.

Treatment.—The successful treatment of lupus requires great patience and endurance on the part of both patient and surgeon. The only local application which is useful is pyrogallic acid applied in a saturated ethereal solution, or a ten to fifteen per cent. ointment, renewed every few days, and followed by mercurial ointment. Solid caustic potash or nitrate of silver with sharp points bored into the tissue will destroy it. A more elegant method of cauterization is the use of the small platinum galvanocaustic apparatus. Linear scarification with a sharp scalpel is a good method of treatment, the formation of cicatricial tissue in the little wounds isolating and strangulating the included nodules. The disease may be removed also by the curette, by the dentist's burr operated by the dental engine, or by complete excision followed by skin-grafting. Excision is often impossible on account of the situation of the disease, and it is said that recurrence is frequent, but the relapse is probably due to the fact that the parts were not removed widely enough. If sufficient perseverance is exercised, a cure may be expected in spite of numerous relapses after long and tedious treatment, in all except the worst cases.

VEGETABLE PARASITIC DISEASES.

Tinea versicolor, due to the *microsporon furfur*, is characterized by yellow or brown patches of various sizes and shapes, chiefly appearing on the trunk, and scaling slightly when scratched. It may cover the entire trunk, and even the limbs and face as well, with one sheet of brown. Its progress is slow, but it is very persistent. It is usually seen in adults, and is of very little clinical significance.

Treatment.—The parasite may be eradicated by soap and water followed by a solution of sulphite or hyposulphite of sodium (ʒi to ℥i), or of resorcin (gr. x to xxx to ℥i), or by the latter in ointment.

Tinea trichophytina, or **ringworm,** is due to the *trichophyton*, and is more contagious than the last-mentioned. It usually presents sharply limited, slightly elevated, congested patches, which scale superficially. The patch spreads at the edges, healing in the centre. When first seen it is half an inch or more in diameter, and there may be several patches. The spots tend to become stationary after a time, although large circinate patches may be formed by coalescence. It is marked by itching, and is common in children. In adults it is seen most often on the inner side of the thigh—the so-called **eczema marginatum**. When it occurs on the scalp or beard the hair becomes brittle and breaks off near the skin, and occasionally pustules form. The hair returns after the disease is eradicated. In the beard it is known as **tinea sycosis**, or **barber's itch.** There is also a so-called **non-parasitic sycosis** characterized by the formation of pustules in the hair-follicles, and caused by infection with pyogenic germs, with which the form due to tinea must not be confounded.

Treatment.—The treatment of ringworm consists in the application of parasiticides, such as hyposulphite of sodium, iodine, balsam of Peru, nitrate of silver (strong solution), carbolic acid, or corrosive sublimate, one to four grains to the ounce. It is most obstinate upon the scalp, where epilation may be required, and relapses are frequent in all situations.

Tinea favosa, or **favus,** caused by the *achorion Schönleinii*, is quite rare in this country. It is recognized by its cup-shaped crusts, each penetrated by a hair, yellow in color, brittle, with a mouse-like odor, accompanied by invasion of the hair-follicle and falling of the hair. Permanent alopecia results. The disease is most common on the scalp, but occurs elsewhere, and may attack the nails. It is very contagious, and is more common in children than in adults. A cure is difficult to obtain. The crusts must be removed, the hair removed by epilation, and corrosive sublimate or oleate of mercury applied.

Animal Parasites.—When **lice** are present (**phtheiriasis**) in small numbers their presence may be betrayed only by the itching, the scratch-marks, and the "nits" or eggs in the hair. Lice are frequently the cause of enlargement of the lymphatic glands of the neck. The body-lice (pediculi corporis and pediculi pubis, or crab-lice) are a different species from those of the head, the latter being smaller. **Treatment.**—Lice may be removed from the head by thorough washing with kerosene or tincture of cocculus indicus. Those of the body live in the clothing, although they may take refuge in the hair of the pubes and the axillæ, and a change of clothing (to be sterilized by steam or by baking in an oven) will dispose of most of them. The remainder can be removed by bathing and by applying oleate of mercury or tincture of cocculus indicus to the hair of the pubes and axillæ, care being taken not to mercurialize the patient if the former application is used.

Scabies (the itch) also betrays its presence by scratch-marks. The parasite usually first appears between the fingers or on the prepuce, and close examination will generally show the presence of a dark red spot about the size of the eye of a needle by which the insect has entered the skin, and the faint gray or black line on the epidermis leading from that point show-

ing where it has burrowed under the epidermis, and it can often be dug out with a needle-point at the farthest end of the burrow. **Treatment.**—The parasite can be destroyed by a hot bath, followed by inunctions of sulphur and balsam of Peru, āā ʒi, petrolatum ʒi, twice daily for three days, after which the patient takes a hot bath and changes all his clothing.

A curious affection may be mentioned here, although it is quite as much a disease of the subcutaneous tissues as of the skin—namely, **dermatolysis,** which is characterized by a redundancy of the skin, the latter at the same time being so loosely connected with the underlying parts that it can be lifted up, and even hangs in loose folds by its own weight. The cause of this rather rare affection is not known, nor is there any efficient cure, although when it is of limited extent excision might be practised.

Tumors of the skin (including warts) are considered elsewhere. But we may note here the **callosities** which form on parts exposed to pressure, called **corns** when they attain great thickness over limited areas, and the so-called **horns.** Callosities are ordinarily of little significance, but occasionally some infection reaches the base, and very troublesome inflammation is the result, which is best treated by early incision if it does not disappear in twenty-four hours of treatment by wet dressings or poultices. To remove callosities, the best application is salicylic acid in ointment or collodion (ten per cent.). Callosities are merely thickened layers of cornified epithelium in the upper layers of the skin, but in corns the process extends deeper, the cornified epithelium collecting between and displacing the papillæ themselves, which may also be hypertrophied. Corns are to be treated by soaking them in hot water and scraping them down when soft, or by the application of salicylic acid in a ten per cent. ointment or solution in collodium. It is possible by a thin but not too sharp knife to extirpate the corn without bleeding, but recurrence is more apt to take place than when the epidermis is more gradually removed, and infection is very likely to occur; in fact, inflammatory conditions of the feet very commonly originate in improper surgery applied to corns. A **soft corn** is merely an ulcerated fissure between the toes or in the folds of skin near them, with some thickening of the epithelium at its edge. It should be treated like any other ulcer, by sterilization, dry dressing, rest, and, if necessary, by incision, followed by rest until complete healing takes place. The horns which are occasionally observed growing from the skin of individuals who are careless as to proper washing are generally found on the forehead or on the glans penis. They are simply accumulations of cornified epithelium and dirt, and generally take their origin from a wart, and in consequence hypertrophied papillæ will be found beneath them. They may attain a length of several inches.

The Nails.—The nails are subject to certain diseases and trophic changes. Occasionally they become detached and fall out without apparent reason, or they are insufficiently cornified and remain soft and fleshy, or they may hypertrophy and become like animals' claws. (Fig. 249.) None of these conditions admit of treatment other than extirpation by removal and destruction of the matrix. Inflammatory conditions due to the usual infections are observed about the nails, known as **onychia** when the matrix itself is attacked, and as **paronychia** if the disease is simply adjacent to

the nail, involving the matrix only partially. The former is most common in syphilis, and consists of chronic ulcers at the base and sides of the nail, resulting in the loss of the latter, and easily cured by the ordinary anti-syphilitic remedies. Paronychia, or panaritis, is frequently confounded with felon or whitlow, but, although paronychia is often followed by the deeper infection, the term should be reserved for a more limited disease originating in a hangnail or in some minute wound. It is marked by a tender, reddened swelling of the fold of skin at the side of the nail, sometimes extending around the entire edge towards the matrix. It may end in resolution or suppuration, and treatment should be very energetic and prompt in order to avoid the deeper infection of felon. This is conducted on the lines explained in the chapter on Inflammation. In its more chronic form paronychia may result in a permanent sluggish inflammation with great hypertrophy, or ulceration, these forms being usually due to syphilis or some continued infection, or to irritation with arsenic, potash, etc.

Fig. 249.

Cornu unguale. (Dumesnil.)

Ingrowing Toe-Nail.—The most common and distressing affection of the nails is the so-called **ingrowing toe-nail**, which usually begins by an irritation set up in the fold of skin at one or both sides of the nail, caused by some minute wound or the pressure of a tight shoe. The skin thickens and presses against the corner of the nail and ulcerates, and the patient is very apt to cut away the nail still more, forming a sharp corner in the nail farther back, which causes additional irritation. The affection is really one of *overgrowing skin*, not of ingrowing nail. The ulcer which develops at the side of the nail deepens constantly, and the corner of the nail may entirely perforate the swollen skin. (Fig. 250.) Ingrowing nails are occasionally, though rarely, observed upon the fingers, sometimes resulting from the habit of biting the nails short. Prophylaxis demands that the toe-nail should always be cut squarely across at right angles to its long axis, and the corners left untrimmed and long enough to reach well beyond the folds of skin on each side, so that the latter cannot be injured by them.

Fig. 250.

Ingrowing toe-nail perforating the skin.

Treatment.—If seen early, the application of some soothing, cold, wet dressing until inflammation is subdued, and the introduction of a little lint

between the corner of the nail and the skin which projects over it, will effect a cure. An over-saturated solution of alum (℥vi to ℥i of *hot* water) will assist the action of the lint by its astringent action, or tincture of benzoin and collodion may be applied on the lint. In severer cases a prolonged treatment may be necessary before the lint can be inserted. The lint treatment, although apparently mild, is as painful as a cutting operation, and will often necessitate the use of cocaine. Of the various operations, Anger's will give the best results for ordinary cases. A narrow sharp-pointed knife is made to transfix the soft parts on the affected side, just grazing the bone at a point level with the highest extent of the matrix, and is carried forward so as to cut a flap from the side of the toe, the flap being as wide as possible, and with its apex well forward at the end of the toe. This flap is held aside, and the knife applied to the bone inside of the base of the flap, directed forward, and the matrix shaved off the side of the bone with a strip of nail and the affected area of soft parts. The flap is returned and secured in place with two or three sutures. Every possible antiseptic precaution must be employed, and primary union will generally be obtained for the greater part of the wound. It is best to keep the foot at rest, but we have obtained perfect results in patients who insisted upon going about during healing. For cases with much infection of the soft parts Cotting's operation is preferable. In this method no flap is cut, but the knife is carried down to the bone at the same high point, so as to include the entire matrix at that side, and carried forward in a sweep, so as to slice off at once the entire side of the toe, matrix, corresponding nail, and soft parts. The wound is left to granulate. The method is a good one, but healing is sometimes tedious on account of the large size of the wound. We have used skin-grafts from the excised skin to cover the raw surface with success. Finally, for cases which obstinately recur, or in which the nail has become greatly deformed or the entire matrix inflamed, it is best to extirpate the entire nail and matrix. A rectangular flap of skin is turned up from the base of the nail, with the base of the flap directed upward towards the foot, and the matrix removed thoroughly with the knife. It is exceedingly difficult to eradicate the matrix entirely, especially the two points which run high up on each side of the phalanx. For all these operations cocaine anæsthesia may be employed. In our hands these operations are preferable to the old plan of avulsion of the nail, being less likely to be followed by recurrence, and not involving any more delay or suffering for the patient.

CHAPTER XV.

SURGERY OF THE LYMPHATIC SYSTEM.

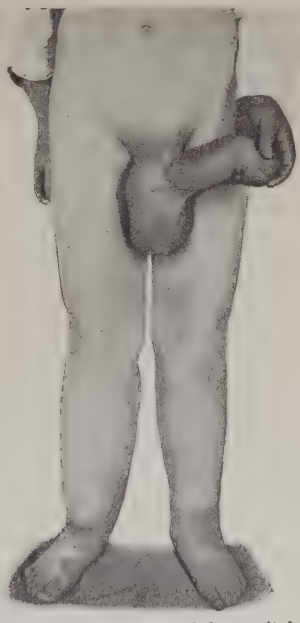
THE peripheral lymph-vessels are liable to injury, inflammation, occlusion, dilatation, or the development of tumors. **Injuries** of the lymph-vessels are, as a rule, of little importance, for, although it is questioned whether new vessels are formed in wounds, the anastomosis is usually so complete as to prevent stagnation of the current.

Obstruction of the lymphatics is seen more frequently as the result of inflammation than of injury, manifesting itself by dilatation of the larger vessels and hypertrophy of the skin and subcutaneous tissues, producing the condition known as elephantiasis. (Fig. 251.) The skin is rough, and the papillæ and folds are thickened, with a tendency to the production of warty outgrowths. The subcutaneous tissue is thickened, resembling œdema, but not pitting upon pressure. In rare instances the bones are also hypertrophied. The most frequent situation of this lymphatic overgrowth is on the lower extremities and the genitals, although it has been observed on the upper extremities. The hypertrophy may reach such an extent as to make the limb several times its normal diameter, while the huge folds of the skin add to the deformity. This condition is sometimes produced by the presence of parasitic filaria in the blood, which enter

FIG. 251.

Elephantiasis of the leg from chronic ulcer and inflammation.

FIG. 252.



Elephantiasis Arabum of the genitals and lower extremities. (Harte.)

and occlude the lymph-vessels, and is then known as true elephantiasis, or elephantiasis Arabum. (Fig. 252.) In many cases this hypertrophy is present at birth or develops immediately after, implying a congenital occlusion or insufficiency of the lymph-channels. The dilated lymphatic vessels are rarely large enough to be of importance externally, for the so-called lymph-sacs of the neck develop from lymphangiomatous tumors and are cysts rather than dilated vessels. Internally, however, cysts of large size may form in the mesentery from dilatation of the chyle-vessels, giving the usual symptoms of abdominal cysts and necessitating operation.

Lymphatic Fistulæ.—When a large lymphatic vessel is divided it sometimes fails to heal, and a fistula is produced, which discharges lymph upon the surface of the skin. The most common situation of lymphatic fistulæ is in the groin. They are of little clinical significance apart from the annoyance caused by the constant moisture of the parts. A fistula of the thoracic duct is sometimes the result of its rupture or division, and may cause an effusion of chyle and death by starvation unless there be an anastomosis with the other side sufficient to carry on the transmission of the chyle into the veins, for no surgical treatment of the injury is possible.

Lymphangitis.—Inflammation of the lymphatics, or lymphangitis, may occur in the acute or the chronic form, with or without a perilymphangitis. When the superficial vessels are affected, a pink line, associated with localized tenderness, marks their course upon the skin, such as is so frequently seen extending up the arm from an infection in the hand. A deep lymphangitis may give no signs externally. In the chronic form the vessel is felt as an insensitive cord, in which the beads produced by its valves can sometimes be distinguished, rolling under the finger beneath the skin, the condition being often found in the penis in syphilis. The inflammation may end in resolution, or result in numerous points of suppuration. The treatment consists in wet dressings or poultices in the acute stage, and counter-irritation with iodine or the thermo-cautery in the chronic. The part must be placed at rest, any limb which may be affected being secured on a splint.

Lymph-Nodes.—The lymph-nodes, known also as *glands* or *ganglia*, act as filters, arresting solid particles, bacteria, and even the chemical impurities of the lymph, and purifying the latter as it passes through them. They are, therefore, often involved in any infectious disease, although they seem to possess great resisting powers to infection and prevent the spread of the disease to parts beyond, or at least hinder its advance until they are themselves overwhelmed by the poison. When their resisting power is overcome, in suppurative inflammations they form abscesses, in the chronic granulation-inflammations they become infiltrated with tuberculous or syphilitic tissue, and in neoplasms they develop the characteristic tissue of the tumor concerned. Even in this condition of surrender to the invasion, prompt removal of the original lesion (inflammatory or neoplastic), together with the lymph-nodes affected, will often prevent generalization of the disease.

Inflammation.—Inflammatory enlargement of the glands, or *lymphadenitis*, whatever its cause, is shown by the growth of those glands which

were previously evident and the appearance of some formerly too small to be detected. A considerable number of glands are apt to be affected, beginning in the region nearest to the primary source of infection. At first they are freely movable under the skin and on the deeper parts, but if suppuration occur the inflammation may spread to the neighboring cellular tissue, and they then become fixed and the overlying skin becomes adherent and reddened. Pain will usually appear at this time, if not already present. The inflammation may terminate in resolution, and the gland may return to its original size or remain permanently enlarged.

Abscess.—In abscesses arising from the lymph-glands it is important to distinguish between the acute and the chronic, and especially with reference to the form of infection. The acute suppuration caused by some virulent septic infection may be of the most threatening nature, especially if the glands lie deep under some strong fascia, as in that form of cellulitis of the neck known as Ludwig's angina ; and, on the other hand, the abscess which forms from a tuberculous gland has all the mildness of a cold abscess. It is also important to distinguish between a simple adenitis and one complicated by a periadenitis, the pus being contained in the capsule of the gland as if in a sac in the first case, whereas there may be a diffuse infiltration of the surrounding cellular tissue in the second. Cold abscesses are not without danger, for the vessels with which they come in contact may be attacked, especially at their forks or where they are exposed to pressure in the flexures of the joints. The wall of the vessel may be simply dissolved, as it were, the process being known as *arrosion*, or a fibrous degeneration may be set up in the muscular coat. Glandular abscesses show this tendency most frequently in persons exhausted by disease, especially in the convalescence from scarlet fever, which appears to have a very injurious effect on the glands. The possibility of such changes in the vessels makes it necessary to exercise great care in opening these abscesses, for the sudden removal of external pressure may be followed by the bursting of a weakened wall in a large vein, or even in an artery, with a fatal hemorrhage. When this accident occurs it is very difficult to secure the injured vessel, owing to its depth and to the diseased nature of its wall, and it may be necessary to ligate it at a distance. The glandular abscesses may undergo absorption, or the pus may be converted into a stringy, almost clear, fluid, forming a sort of cyst ; but these terminations are rare. More common is the calcification of glands which contain minute foci of pus or degenerated tissue. The manner in which glandular abscesses discharge, if left to themselves, is characteristic. The pus is very slow in reaching the surface, fluctuation being evident long before the skin sloughs over a very small area in the centre, and the discharge persisting through this small opening for a long time. The opening is usually surrounded by bluish undermined skin, and unhealthy granulations may protrude from it. If there is periadenitis the remains of the gland may be found in the cavity of the abscess, not much altered in appearance.

The diagnosis between simple or inflammatory hypertrophy and the development of sarcoma in a gland is generally possible, even if no marked signs of inflammation are present, for in hypertrophy there are usually

several glands enlarged, and a peripheral lesion can in most cases be found to account for the infection. Hypertrophy is distinguished from malignant lymphoma by the fact that in the latter several or all of the groups of lymphatic glands are involved, while in the former only a single region may be affected.

Treatment.—Resolution may be favored by cold wet dressings, the ice-bag, or counter-irritation with iodine or the thermo-cautery. Suppuration demands incision, and the complete removal of all remaining gland-tissue by the curette or the knife, in order to prevent the formation of troublesome sinuses. When the infection is tuberculous the glands may be excised, or when they have formed abscesses they may be incised and scraped, or aspirated and injected with iodoform, as described on page 61. Syphilitic enlargements will usually disappear under constitutional treatment, although here also extirpation may be necessary for very large and indurated masses.

The so-called scrofulous diathesis undoubtedly predisposes to hypertrophy of the lymph-nodes, even when no characteristic tuberculous change can be found there or elsewhere in the body, and in such individuals the glands should be removed as soon as they enlarge, unless great numbers of them are hypertrophied. It is generally wise to remove hypertrophied glands as soon as it is evident that they will not resolve, for if tuberculous they are a constant menace of constitutional infection, and are also much more difficult to cure after suppuration has taken place.

FIG. 253.

Malignant lymphoma, or Hodgkin's disease.

Tumors.—While the other tumors of the lymphatic nodes are elsewhere described, it will be well to consider in this place the peculiar disease known as *malignant lymphoma* or Hodgkin's disease. (Fig. 253.) Multiple enlargement of the glands is found in leukæmia, but in Hodgkin's disease the blood appears to be normal, and the latter for that reason has been called pseudoleukæmia. In malignant lymphoma one group of glands enlarges without apparent cause, usually in the neck or in the axilla, and the process then spreads to other groups, including the internal glands, especially those of the mediastinum. The patient becomes cachectic, feverish, suffers from diarrhœa, and gradually fails; and at autopsy it is found that there has been a metastasis to the lungs, liver, and other organs. The tumors may be formed of soft tissue like the ordinary hyperplastic lymph-gland, or of a dense, hard, fibrous tissue with spindle-cells, as if the connective-tissue stroma of the glands had increased and caused the disappearance of the softer parts. Nothing is known of the etiology of this disease, nor can anything be done in the way of treatment.

CHAPTER XVI.

SURGERY OF THE BLOOD-VESSELS.

INJURIES OF ARTERIES.

Arteries may suffer from contusion, or from lacerated, punctured, and incised wounds.

Contusion of Arteries.—This form of injury is probably much more common in subcutaneous injuries than is generally supposed, as in the case of extensive contusions many arteries are necessarily involved, but it is only when an artery of considerable size is severely injured that distinctive symptoms arise by which the nature of the injury can be recognized. A severe localized contusion of an artery may result in partial or complete laceration of the inner and middle coats, the external coat remaining uninjured; in consequence, a thrombus forms in the vessel, and subsequent obliteration of the vessel at the point of injury may occur, or the force of the blood-current may distend the external coat, giving rise to an aneurism or to rupture of the external coat, producing a diffused aneurism. Complete rupture of all the coats may follow contusion of an artery, which in the smaller vessels is followed by retraction and curling up of the divided ends, so that little blood escapes, and healing with obliteration of the vessel occurs. In larger vessels complete rupture is followed by the rapid escape of blood, with the constitutional symptoms of concealed hemorrhage, and a tumor rapidly forms at the seat of injury, in which slight pulsation may be discovered. The later results of contusion of arteries depend upon the loss of blood-supply to the parts supplied by the injured vessels, and may be shown by loss of color, by coldness of the parts, and by ulceration or gangrene; if sloughing of the skin over the tumor takes place, hemorrhage occurs.

Symptoms.—If after contusion of an artery pulsation immediately or slowly disappears from the vessel below the seat of injury, it is probable that a thrombus has formed, and if sloughing of the vessel at the seat of injury does not occur and the collateral circulation is established, the vitality of the parts supplied by the vessel is retained. We have seen cases of contusion of the brachial artery at the elbow and of the femoral artery in Scarpa's triangle followed by obliteration of these vessels, where the vitality of the parts below was maintained. In many cases so fortunate a result does not occur; an aneurism may form at the seat of contusion of the vessel, or gangrene may occur in the parts supplied by the vessel, or subsequent sloughing of the vessel at the seat of injury may give rise to secondary hemorrhage or to the formation of a diffused aneurism.

Treatment.—In contusion of an artery followed by obliteration of the vessel, the early treatment consists in putting the part at rest, and the application of warmth to the parts supplied by the occluded vessel, to encourage and maintain their vitality; if this is maintained, the patient should be kept quiet for a few weeks, to allow the collateral circulation to be perfectly established and to permit of the satisfactory organization of the blood-clot at the seat of injury. Contusion of an artery, followed by the appearance of a tumor at the seat of injury, with or without pulsation, and with impairment of the circulation in the parts supplied by the vessel and obstruction of the return venous circulation, should be promptly treated by the exposure of the injured artery by incision and turning out of the blood-clots which largely produce obstruction to the return circulation, and the application of two ligatures to the injured artery at parts where the vitality of its coats is unimpaired. If the vessel has not been completely divided, its division should be completed, to permit of retraction of its ends. Esmarch's apparatus will be found very useful in these cases in controlling the bleeding, and thus assist in locating the point of rupture of the artery.

Laceration of Arteries.—Laceration of arteries, even of considerable size, is usually accompanied by little primary hemorrhage, owing to the fact that the inner and middle coats tear and curl up within the artery, and the outer coat is stretched beyond the limit of its elasticity and breaks, leaving a frayed edge, which falls over the end of the artery; a blood-clot soon forms upon the roughened edges of the inner and middle coats, which arrests the bleeding; the proximal end of the vessel can often be seen pulsating in the wound almost down to its extremity, and yet no blood escapes. Laceration of arteries results from the same causes that produce laceration of muscles, nerves, and fasciæ, and is most commonly seen in machinery and railroad accidents and in cases of avulsion of the limbs. Primary hemorrhage in laceration of arteries, as previously stated, is often insignificant, but if the damage to the vessel has been great enough to interfere with its vitality, or if the wound becomes septic, sloughing is apt to take place and secondary hemorrhage is very likely to occur.

Treatment.—In an aseptic wound repair of a lacerated artery may take place, and with this possibility in view some surgeons recommend that a case presenting such a condition should be carefully watched, and that no active treatment as regards the injured vessel be employed unless secondary bleeding occurs. Although lacerated arteries in aseptic wounds may heal without the occurrence of secondary hemorrhage, we think the treatment above mentioned is not to be recommended, as it entails an element of risk to the patient which we do not consider justifiable. We consider it a safer method of treatment in the case of laceration of the larger arteries to secure both the proximal and distal ends of the vessel in the wound by ligatures applied to a part of the vessel at which there is no question as to its vitality; the contused and lacerated portion should be cut away between the ligatures.

Punctured Wounds of Arteries.—These are always serious injuries, although at the time of their occurrence they may appear to be trivial. These injuries are produced by stabs with sharp narrow knives, by splinters of metal, glass, wood, or bone, and by nails, needles, or any sharp-pointed

instrument. Hemorrhage in punctured wounds of arteries is apt to be continuous, as the clot does not extend into the artery but is deposited outside of it, and, as the wound is a small one, the blood infiltrates the tissues, causes pressure upon the veins, and interferes with the return venous circulation, or a diffused aneurism results. If the wound has been infected by the vulnerating instrument or becomes septic later, septic arteritis develops and secondary hemorrhage is apt to take place.

Treatment.—In view of the above-named complications which may follow punctured wounds of arteries, the treatment which is most judicious consists in exposing the artery freely by an incision at the site of the wound, with due care as regards asepsis, and in applying ligatures to the vessel on each side of the puncture, and subsequently dividing the artery completely at the site of the puncture. If the accompanying vein has also been punctured and bleeds, it should be secured by two ligatures or by the use of a lateral ligature or sutures.

Incised Wounds of Arteries.—These are among the most frequent wounds of arteries which come under the care of the surgeon, and may be produced by accidental division by sharp instruments, or by the surgeon in operating. The artery may be incised longitudinally, transversely, or obliquely. Longitudinal wounds gape very little, and may heal promptly. Transverse wounds, if completely severing the artery, are accompanied by marked contraction of the ends of the vessel and their retraction within the sheath.

Symptoms.—Incised wounds of arteries are, as a rule, accompanied by free hemorrhage. In longitudinal and small incised wounds the primary hemorrhage may not be great, but, as the lumen of the vessel is not occluded, the bleeding is apt to be continuous, and a diffused aneurism is likely to form. In incised wounds of small arteries, hemorrhage may be arrested by the formation of a clot in the retracted end of the vessel. In incised wounds of the larger arteries the hemorrhage is so profuse that a fatal result quickly follows. When the main artery of a part is partially or completely divided, the parts supplied by it become cold and blanched, and the vitality in these tissues is determined by the promptness with which the collateral circulation is established; if this is not accomplished, or is incompletely established, gangrene of the parts to a greater or lesser extent occurs.

Treatment.—In incised wounds of arteries hemorrhage may be controlled by torsion or the application of ligatures; torsion seems most applicable to division of the smaller vessels, and in any vessel of considerable size a ligature should be applied to both ends of the divided vessel. If the vessel has been only incompletely divided, it should be completely divided after the ligatures have been applied. Small incised and lateral wounds of arteries should be treated in the same manner. In the treatment of a wounded artery, the safety of the patient demands the obliteration of the vessel at the seat of injury. Recent experimental investigations and clinical experience, however, have shown that it is possible to close wounded arteries by sutures, and thus prevent obliteration of the vessel at this point.

Gunshot Wounds of Arteries.—Gunshot wounds of arteries are occasionally seen in civil practice, but are frequent in military surgery. A

bullet, according to its velocity, may simply contuse an artery, may tear away a portion of it, or may perforate it or completely divide it. If the vessel has been simply contused, no hemorrhage results, and if the wound remains aseptic the vitality of the vessel may be retained, and repair take place without marked change in its lumen. Contused wounds of arteries, if infection and sloughing occur, are usually followed by secondary hemorrhage at the end of a week or two. Laceration or complete division of the artery causes profuse primary hemorrhage, the blood escaping from the external wound, or in wounds of deep vessels it may be extravasated in the tissues, giving rise to a diffused aneurism. Gunshot wounds of large arteries, if complicated by wounds of the accompanying veins, are likely to be followed by gangrene. Gunshot wounds of arteries are often complicated by the presence of foreign bodies driven into the tissues with the ball, such as portions of the clothing, and may be further complicated by coincident fracture of the bones and wounds of nerves. Infection of the wound may result from the introduction of foreign bodies.

Treatment.—In gunshot wounds accompanied by free hemorrhage, if involving the large vessels of the extremities, an Esmarch's bandage should be applied, an incision should be made exposing the wound in the artery, and the vessel should be secured by two ligatures applied above and below the wound; if the accompanying vein is only nicked or partially divided, a lateral ligature or sutures should be applied; if extensively injured or completely divided, it should be secured by two ligatures applied above and below the wound. Where there is little external hemorrhage, but bleeding into the tissues, as evidenced by change in color of the limb and swelling near the seat of injury, the artery should be exposed by incision at the point of injury, the blood-clot should be turned out, and the vessel should be ligated as previously described. If gunshot contusion of an artery is not followed by immediate occlusion of the vessel at the seat of injury, the part should be put at rest and the wound kept aseptic. Under such treatment repair may take place in the wounded artery without the development of serious symptoms. If, however, secondary hemorrhage occurs, the artery should be exposed in the wound and ligated in a healthy portion by two ligatures. If this cannot be satisfactorily done, it should be exposed above the wound and tied.

Primary traumatic gangrene following a gunshot wound of an artery of the extremities, if rapidly developed, usually requires amputation of the limb at as high a point as the injury of the artery. If gangrene occurs later, after the artery has been secured in the wound, and is localized, the surgeon should wait for the formation of the lines of demarcation and separation before resorting to amputation.

HEMORRHAGE.

Hemorrhage always occurs after wounds of the blood-vessels, and may be so slight in amount as to produce little local or constitutional disturbance, but if large vessels are injured it may be profuse, and attended with great danger to life. The blood may escape through an open wound, or be extravasated into the tissues or into some of the cavities of the body.

In either event the danger to the patient depends upon the amount of blood which escapes from the circulation and the rapidity with which it is lost. Profuse hemorrhage is the most alarming and trying emergency that comes under the care of the surgeon, and its prompt and proper treatment requires presence of mind and judgment. In no class of cases in surgery are these attributes of the surgeon better shown than in the management of this emergency.

The varieties of hemorrhage are classified, according to the source of the bleeding, as *Arterial*, *Venous*, *Capillary*, and *Parenchymatous*, and also according to the time of the bleeding, as *Primary*, *Intermediary* or *Consecutive*, and *Secondary*.

Arterial Hemorrhage.—This occurs from a wounded artery, and the blood is scarlet in color, and escapes in jets from the proximal end of the vessel synchronously with the cardiac pulsations. Blood from the distal end of the artery does not escape in jets, but flows in a continuous stream. Although arterial hemorrhage is generally characterized by a bright red color, it should be borne in mind that in cases where the proper aëration of the blood does not take place, and carbonic oxide is present in excess, dark-colored blood may escape from arteries. This is often observed in operating upon patients who present profound narcosis from an anæsthetic, or in the operation of tracheotomy when no anæsthetic has been employed.

Venous Hemorrhage.—This variety of hemorrhage is characterized by the escape of dark-colored blood in a continuous stream from the injured vein, due to the fact that there is no cardiac impulse in the veins.

Capillary Hemorrhage.—In this variety of hemorrhage there is oozing of blood from numerous points upon the surface of a wound, and, although the amount of blood escaping from each point is small, if the bleeding continues for any considerable time and the wound surface is extensive, a sufficient amount of blood may be lost to endanger the life of the patient. Wounds of the mucous membranes, where the capillaries are large and abundant, are often followed by free capillary hemorrhage.

Parenchymatous Hemorrhage.—This occurs from wounds of tissues which present certain anatomical peculiarities of arrangement of the blood-vessels; for instance, in erectile tissue, where the arteries terminate in the veins without the intermediate capillary system, or in tissues in which the normal vascular arrangement is altered by disease. Parenchymatous hemorrhage is observed in wounds of the spleen and of the corpora cavernosa, and in organs whose structure is changed by the presence of carcinomatous or sarcomatous growths.

Primary Hemorrhage.—This may be arterial, venous, or capillary, and occurs immediately upon the injury of the vessels.

Intermediary or Consecutive Hemorrhage.—In this variety of hemorrhage the bleeding occurs a few hours, usually within twenty-four hours, after the operation or injury, when reaction is established, and results from detachment of occluding clots from the vessels, which are forced out as the arterial pressure increases. Consecutive hemorrhage may also result from the detachment of improperly applied ligatures and from the disturbance of ligatures by the movements of the patient.

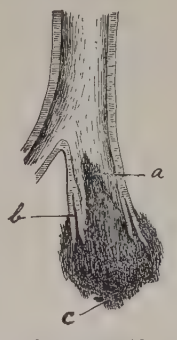
Secondary Hemorrhage.—This variety of hemorrhage may occur at any time after twenty-four hours following the wound of the vessel; it is most common from the beginning to the end of the second week, and results from incomplete repair of the injured or ligatured vessel, or from ulceration of the injured vessel due to a septic arteritis. This condition may arise from the introduction of infective material by the instrument causing the wound, or by an imperfectly sterilized ligature. Secondary hemorrhage may also arise from rupture of a wounded artery by increase of the blood-pressure before the cicatrix is firm enough to resist the pressure. Atheroma of the arteries and certain constitutional conditions, as diabetes and advanced renal disease, diminish the resistance of blood-vessels to septic infection and thus predispose to secondary hemorrhage. Secondary hemorrhage was formerly one of the most common and dangerous of wound complications, but now, when aseptic healing of wounds is very general, it is rarely seen.

Constitutional Symptoms of Hemorrhage.—Excessive hemorrhage is marked by a rapid, small, quick, and weak pulse, which may not be detectable in the small arteries, such as the radial or the ulnar, but may be feebly felt in the femoral or the carotid. The skin becomes white, cold, and bathed in sweat; the mucous membranes become blanched. The breathing is rapid, and the patient complains of shortness of breath and great thirst; nausea and vomiting may be present. The voice is feeble, muscular weakness is marked, the patient becomes restless, and has severe cramp-like pain in the limbs, convulsions may occur, and finally syncope develops. The temperature is subnormal. In recurrent hemorrhage the total amount of blood lost may be very great before death occurs; the patient loses blood until syncope results, and then partially reacts before hemorrhage recurs. After repeated hemorrhages the blood becomes thin and watery, œdema of the eyelids, scrotum, and extremities is usually developed, and the feeble action of the heart may be suddenly arrested if the patient makes any severe exertion or is raised suddenly in bed. After recovery from serious hemorrhage there is often developed a condition known as *hemorrhagic fever*, which is characterized by an elevation of the temperature and increase and irregularity in the pulse-rate, thirst, and scantiness of the urine; the patient is in an asthenic condition and presents marked disturbance of the nervous system, as shown by low, muttering delirium. The condition is not the effect of septic poisoning, but results from the absorption of fibrin ferment and the imperfect supply of blood to the great nerve-centres. After excessive loss of blood the patient is often left in an anæmic condition, from which he recovers very slowly. Recovery from the anæmia following profuse hemorrhage is rarely complete in advanced life.

Spontaneous Arrest of Hemorrhage.—In a large number of cases natural arrest of hemorrhage takes place before the loss of blood is fatal. When an artery is completely severed the muscular coat contracts, and narrows or completely closes its orifice; this contraction is due to direct stimulation of the muscular fibres of the artery. At the same time the divided artery retracts within its sheath; the contraction, which is both circular

and longitudinal, tends to narrow the orifice of the vessel and also draw it away from the surface of the wound. The contraction and retraction of the ends of the divided artery, with narrowing and roughening and curling up of the coats, are quickly followed by the development of a blood-clot or *coagulum*, which forms first in the sheath of the artery and covers the end of the vessel; this constitutes the *external* clot. Blood also coagulates within the divided artery, and often extends so as to fill the vessel to the first large collateral branch; this is the *internal* clot. (Fig. 254.) The portion of the clot which is attached to the end of the divided vessel, between the external and the internal clot, is known as the *central* clot. The presence of these clots causes the temporary arrest of the bleeding, and by their subsequent organization hemorrhage is permanently arrested and the artery is obliterated at the seat of injury. Syncope, which diminishes the cardiac action and thus reduces the force of the blood-current, favoring the coagulation of blood in the divided vessel, is often an important factor in the spontaneous arrest of hemorrhage. Complete division, contusion, or laceration of an artery favors the spontaneous arrest of hemorrhage, whereas incomplete division of the vessel, adhesion of the vessel to its sheath, movements of the patient displacing the forming clot, and stimulation of the heart all tend to prevent the arrest of bleeding. In wounded veins the spontaneous arrest of hemorrhage occurs very much in the same manner: contraction and retraction of the veins are not marked, but the walls of the cut vein collapse, which serves the same purpose, and the coagulation of blood takes place, forming an external, an internal, and a central clot. Where the walls of a vein are attached to firm tissue and cannot collapse, as in the venous sinuses in the skull, spontaneous arrest of hemorrhage cannot occur. The presence of valves in veins between the wound and the heart also prevents the flow of blood from the cardiac end of the vein.

FIG. 254.



Coagulum in divided artery: *a*, internal, *b*, central, *c*, external, clot.

Diagnosis of Hemorrhage.—This is a matter of little difficulty if blood escapes from an open wound, but when a vessel has been injured subcutaneously, or blood escapes into the great cavities of the body, constituting what is known as *concealed* hemorrhage, it is often difficult for a time to recognize the condition. If in the latter case the escape of blood is profuse, the patient soon exhibits the constitutional symptoms of hemorrhage, which are often associated with the presence of a swelling, giving rise to certain mechanical disturbances, which lead the surgeon to the proper solution of the problem. The greatest confusion is apt to arise in cases of hemorrhage into the pelvic, pleural, abdominal, and cranial cavities, where the symptoms presented closely resemble those of shock; and as both conditions follow similar injuries and may coexist, their differentiation is often a matter of the greatest difficulty, and the diagnosis can be arrived at only by a careful study of the special symptoms and physical signs presented in each case.

TREATMENT OF HEMORRHAGE.

Constitutional Treatment of Hemorrhage.—The first indication in the constitutional treatment of hemorrhage is to put the injured part at *rest* and secure for the patient complete rest in the horizontal position, which lessens cardiac action, diminishes arterial tension, and prevents cardiac exhaustion and displacement of blood-clots which have formed in the vessel at the seat of injury.

If hemorrhage is taking place, this should be controlled before attempts are made to bring about reaction. After serious bleeding the temperature is usually subnormal, and the patient should therefore be surrounded by hot cans or water-bottles and covered with woollen blankets, to maintain the temperature and bring about reaction. Care should be taken that the patient is not so heavily covered that his respiratory movements are interfered with; while he is warmly covered, he should be supplied with an abundance of fresh air. The patient should be given strychnine hypodermically, gr. $\frac{1}{30}$, or ether, ♏ x to xx, and, as soon as he is able to swallow, cardiac stimulants, such as tincture of digitalis, carbonate of ammonium, gr. v, whiskey, or brandy, should be administered. The head should be placed low, to prevent syncope, and in extreme cases, where the tendency to cerebral anæmia is marked, it should be placed lower than the body and the procedure known as *auto-transfusion* may be practised—the limbs being raised and firmly bandaged, to force the blood from them and thus increase the supply of blood to the brain. In cases in which a large amount of blood has been lost and the constitutional symptoms of hemorrhage are marked, transfusion of blood, or, better, the intravenous injection or infusion of saline solution, should be practised. Large enemata of hot water may also be given with good results. Stimulants should be used cautiously if the bleeding has not been controlled by ligature of the wounded vessels, as otherwise their use may cause a renewal of the hemorrhage. The patient should also be given hot water, milk, or concentrated beef extracts or beef tea.

Local Treatment of Hemorrhage.—This consists in the employment of various measures which either temporarily or permanently control the bleeding, and the procedure adopted in special cases depends upon the size of the vessel from which the bleeding comes, the origin of the bleeding, whether arterial, venous, or capillary, and whether it be primary or secondary.

Temporary Control of Arterial Hemorrhage.—**Position.**—In arterial hemorrhage from wounds of the extremities elevation of the part will be found to diminish materially or arrest the bleeding; in hemorrhage from wounds of the hand, forearm, foot, and leg, forcible flexion of the forearm on the arm, or of the leg on the thigh, will very much diminish the force of the blood-current.

Compression.—This may be employed by pressure applied directly to the bleeding vessel in the wound, or to the main artery between the wound and the centre of circulation; compression may be made by the fingers, *digital compression*, by *tourniquets*, by *elastic constriction*, or by *hæmostatic forceps*.

Digital Compression.—This constitutes one of the most valuable means employed for the temporary control of hemorrhage. The finger or fingers are pressed directly upon the bleeding vessel in the wound, or hold a compress in the wound, or make compression upon the artery from which the bleeding arises at some point between the wound and the centre of circulation. (Fig. 255.) Control of hemorrhage by digital compression can be maintained for only a few minutes, as the finger of the surgeon or assistant soon becomes tired; it is therefore employed only until means are adopted for the permanent arrest of the bleeding.

Compresses.—The temporary control of arterial hemorrhage may also be secured by the use of compresses placed directly in the wound or applied to the vessel from which the bleeding arises, between the wound and the centre of circulation, and securely held in position by a bandage. If a compress is applied in the wound it should be made of antiseptic or sterilized gauze, to prevent infection of the wound.

FIG. 255.

Digital compression of the femoral artery. (Agnew.)

FIG. 256.

Spanish windlass applied to the femoral artery. (Agnew.)

Tourniquets.—These instruments, which are of many varieties, are used for the temporary control of hemorrhage, and often serve a useful purpose, but if their use is continued for any considerable time they are apt to cause the patient great pain, and they should be dispensed with as soon as means can be employed for the permanent control of the bleeding.

The Spanish Windlass.—This is an improvised tourniquet which may be employed in cases of emergency, and is prepared by folding a handkerchief or a piece of muslin into a cravat and placing a compress or a smooth pebble in the body of the cravat; this is placed over the artery to be controlled, and the ends of the handkerchief are tied loosely around the limb; a short stick is passed through this loop, and by twisting this stick the loop is tightened and the compress is forced down upon the artery. (Fig. 256.)

Petit's Tourniquet.—This tourniquet consists of two metal plates connected by a strong linen or silk strap with a buckle, the distance between the plates being regulated by a screw. To apply this tourniquet, a compress or roller bandage is placed directly over the artery and held in position by a few turns of a roller bandage. The lower plate of the tourniquet is placed directly over this pad, and the strap is securely buckled around the limb. The screw is then turned so as to separate the plates and tighten the strap, thus forcing the compress or pad upon the artery and controlling its circulation. (Fig. 257.) This instrument is especially useful in controlling the circulation in wounds of the extremities, and is often employed in amputa-

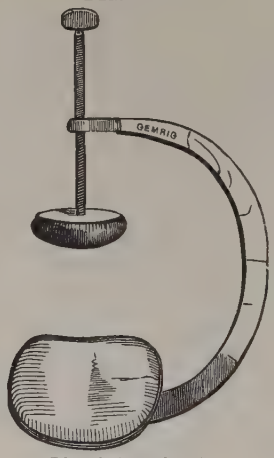
tions of these parts, being placed over the main artery some distance above the seat of operation. Many other forms of tourniquet may be employed, among the most useful being those which are constructed upon the same principle as Lister's tourniquet. (Fig. 258.)

Elastic Constriction.—The elastic tube or strap of Esmarch's apparatus

Fig. 257.

Petit's tourniquet applied to the femoral artery. (Agnew.)

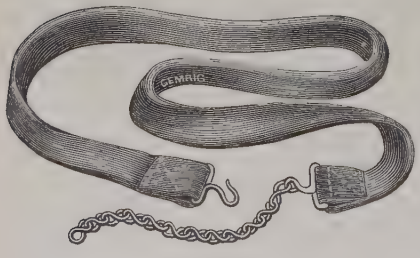
Fig. 258.



Lister's tourniquet.

is now very widely employed for the temporary control of hemorrhage (Fig. 259), but, if it is not at hand, a very satisfactory substitute may be improvised from elastic suspenders or garters, or from a rubber drainage-tube. In hemorrhage from wounds of the extremities, and in operations upon the bones, or for the removal of tumors, or in amputations, elastic constriction is employed with most satisfactory results. By the use of the elastic strap or tube the circulation can be absolutely controlled; but care should be exercised in using this appliance to adjust it with just enough firmness to control the bleeding, and also to allow it to remain in place as short a time as possible, for from its too firm application the muscles have been divided, and nerve-trunks have been so severely injured that permanent paralysis has resulted. Paralysis of the vaso-motor nerves following elastic constriction of a part is very common, and is marked by free capillary bleeding.

Fig. 259.



Elastic strap.

Hæmostatic Forceps.—The employment of hæmostatic forceps for the control of hemorrhage during operations is very general, and has done much to diminish the mortality of operations. The hæmostatic forceps in general use is a self-retaining instrument which is clamped upon the bleeding vessel during the operation, and is allowed to remain in position until the operation

is completed, when the vessel may be permanently secured by the application of a ligature or by torsion. (Fig. 260.)

Permanent Control of Arterial Hemorrhage.—This may be accomplished by the use of pressure, cauterization, the ligature, torsion, or acupressure; cold, heat, and styptics may also be employed for this purpose.

Pressure.—Pressure may be employed to control arterial hemorrhage by means of compresses of antiseptic gauze applied to the surface of the wound, or by means of strips of gauze packed firmly into the cavity from which the bleeding arises. It may be used with the best results where the proximity of a bone furnishes a firm substance upon which the vessel may be compressed, as is the case in the vessels of the scalp. Pressure applied by strips of antiseptic or sterilized gauze will be found a most efficient means of controlling bleeding from cavities such as the nose, the vagina, or the rectum, and in cavities resulting from the removal of necrosed or carious bone. In bleeding from a bony canal, such as the inferior dental canal, a piece of catgut ligature may be forced into the canal, or a piece of Horsley's wax—which is composed of wax, 7 parts; oil, 2 parts; carbolic acid, 1 part—may be forced into the opening of the bone, and will control the bleeding in a satisfactory manner. A material known as *gut wool* has been introduced by Halsted, which is prepared from the same material from which catgut is made. This is cut in strips and is packed into the cavity or canal in the bone from which the bleeding arises. If gauze packing has been used to control bleeding, it should be allowed to remain for some days, until it becomes loose by the development of granulations in the wound, when it can be removed with ease, and usually subsequent packing of the wound is unnecessary.

Fig. 260.

Hæmostatic forceps.

Cauterization.—The use of the actual cautery, applied by means of the hot iron, or Paquelin's cautery, is an efficient means of controlling bleeding. The iron should be only of a dull red heat, as the result desired is not the destruction of the tissues, but the coagulating effect of heat. An aseptic surface results from the application of the cautery. The control of arterial bleeding by cauterization is often made use of in operations upon bone, or in those upon the mouth, pharynx, or tonsil. It is also employed to control hemorrhage in operations upon the uterus and the rectum, where the application of a ligature is difficult.

Torsion.—This method of controlling arterial hemorrhage consists in grasping the end of the vessel with artery or hæmostatic forceps, and drawing it slightly out of its sheath and twisting it (Fig. 261); or it may be accomplished by the use of two pairs of forceps, the vessel being held at a little distance from its orifice by one pair of forceps and twisted with a second pair. Torsion of arteries, preventing the occurrence of hemorrhage, is quite commonly observed in accidental wounds, such as avulsion of a limb; arteries as large as the femoral or the brachial may in these accidents have under-

gone torsion to such an extent that no blood escapes from them, although completely torn across. Torsion has been employed to a considerable extent to control bleeding from arteries, being used in the case of vessels as large as the femoral or the axillary. In the case of large vessels it does not offer the same safety as the application of an aseptic ligature, and we therefore think its most satisfactory application is to small or moderate-sized vessels.

The Ligature.—This is by far the most widely employed method of controlling arterial hemorrhage. The materials used for ligatures are silk or catgut, which should be thoroughly sterilized before being used. The preparation of ligatures is described on pages 167, 168. In securing a divided vessel by a ligature the end of the vessel is grasped with artery (Fig. 262) or hæmostatic forceps, and is separated from the surrounding tissues and slightly drawn out of its sheath. A piece of catgut or silk about ten inches in length is then firmly tied upon the end of the vessel, and is secured by a reef or surgeon's knot. The knot should

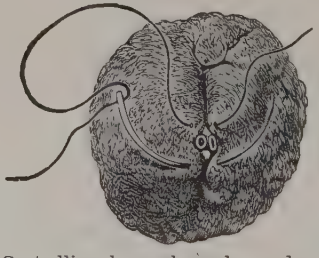
Fig. 261.

Torsion of an artery.

Fig. 262.

Artery forceps.

Fig. 263.



Controlling hemorrhage by a deep suture. (Esmarch.)

be made with firmness, and should not be secured by a jerky motion, which is often done and is apt to break the ligature. The ligature may be tied with only enough force to bring the coats of the vessel in contact, or with sufficient force to divide the inner and the middle coat. The latter method is the safer one. When the knot has been firmly tied the ends of the ligature are cut short in the wound.

In very dense tissues it is often impossible to grasp the end of the divided vessel with forceps. In such cases the hemorrhage may be controlled by the use of a deep suture. (Fig. 263.) This is applied by threading a catgut or silk ligature into a curved needle, then passing the needle deeply into the tissues on each side of the bleeding vessel, and finally securing it by tying.

Both ends of a divided artery should be secured by ligatures, although the distal end may not bleed at the time; when the collateral circulation is established, hemorrhage may take place from it. In the case of a partially divided artery ligatures should be placed upon the vessel on each side of the wound, and after being secured the division of the vessel should be

completed. This permits of contraction and retraction of the ends of the artery.

Suture.—Billroth, Schede, Schmidt, and many others have successfully practised suture of wounds in veins, thereby preserving permeability of the vein at the seat of injury. Murphy has practised experimentally in animals the same procedure both in arteries and in veins, and recommends, when more than two-thirds of the circumference of the vessel has been divided, resecting the injured portion of the vessel where it can be done without removing more than three-fourths of an inch of the vessel, and invaginating one end into the other, securing it by fine silk sutures. In longitudinal wounds the edges may be brought together with fine silk sutures introduced by means of a fine cambric needle; the sutures should be inserted from one-sixteenth to one-twentieth of an inch apart and one-sixteenth of an inch from the edges of the wound, and should include only the adventitia and media, not perforating the intima. During the operation the circulation in the vessel should be controlled, both above and below the wound, by forceps covered with rubber tubing, and where a distinct sheath is present it should be sutured, or, where this is not present, muscle or fascia should be sutured over the closed wound in the vessel.

Styptics.—These are agents which have a marked astringent or coagulating effect upon the tissues, such as Monsel's solution, antipyrin, acetic acid, dry or moist heat, and cold. Styptics were formerly much employed in the treatment of arterial hemorrhage, but at the present time are not much used, except for the control of capillary or parenchymatous hemorrhage.

Hot Water.—Hot water is often employed as a styptic, and controls bleeding by producing contraction of the tissues and coagulation of the albumin: it should be used at a temperature of 115° to 130° F. (45.1° to 54.4° C.) to obtain the best effects. Hot water is not employed to control hemorrhage when arteries of any considerable size are injured, but may be used with advantage in capillary or parenchymatous bleeding. Water which has been sterilized by boiling and cooled down to the proper temperature is a perfectly safe application to wounds. In cases where large oozing surfaces are exposed, as often happens in extensive wounds or in operations upon the abdominal cavity, hot water acts well as a styptic, and has the additional advantage of furnishing heat, which diminishes the shock of the operation. Gauze compresses wrung out of hot water may be packed into wounds to control bleeding, combining the effects of pressure and heat.

Cold Water or Ice.—These substances may be used as styptics, and act by producing reflex vascular contraction, being used in the form of irrigation or an ice-bag. Cold applied in this way is not as efficient as hot water; it also has the disadvantage of chilling the patient and increasing the shock, which may be a serious matter in cases in which profuse hemorrhage has taken place.

Antipyrin.—A solution of antipyrin, five per cent., in sterilized water possesses marked styptic action. As it also possesses antiseptic properties and is not toxic, it may be used without risk to control capillary bleeding from the surface of the brain, intestines, and peritoneum, and from bone-cavities.

VENOUS HEMORRHAGE.

Treatment of Venous Hemorrhage.—Spontaneous arrest of venous bleeding may occur from the action of the same causes that result in the arrest of arterial hemorrhage. Bleeding from small veins is usually arrested spontaneously, unless there is some pressure upon the wounded veins on the cardiac side of the wound, in which case continuous bleeding is apt to occur. Venous hemorrhage may be controlled by pressure, by the use of the hæmostatic forceps or ligature, or by suture of the wounded vessel.

Pressure.—This may be applied for the temporary control of venous hemorrhage by the fingers, or by the use of a compress held firmly over the wounded vessel by a bandage, or by packing the wound with strips of gauze: this method is often employed to control venous bleeding from deep cavities, or from the great venous sinuses within the skull, where a ligature cannot be easily used. Pressure applied in this manner may also be employed for the permanent control of venous bleeding. After venesection, or in cases of rupture of varicose veins, the bleeding is controlled by the use of a compress, which is allowed to remain in place until the wound is healed.

Ligature.—In wounds of large veins the bleeding should be controlled by the use of ligatures, the distal end of the vein being first secured, as it usually bleeds more freely; the proximal end of the vein, if supplied with valves beyond the wound, may not bleed, but in all cases of injuries of large veins it is wise to follow the rule of practice employed in wounded arteries and secure both ends of the vein by ligatures.

Lateral Ligature.—In punctured wounds or incomplete division of large veins it has been found that the hemorrhage may be safely controlled without obliteration of the vein at the seat of injury by the application of a lateral ligature; the walls of the vein, including the wound, are picked up with forceps or hæmostatic forceps, and a delicate catgut or silk ligature is firmly tied around the base of the tissues held in the forceps. The lateral ligature has frequently been resorted to in wounds of the femoral, jugular, and axillary veins, as well as in wounds of the venous sinuses within the skull; and the occurrence of secondary hemorrhage after this form of ligature, if the wound remains aseptic, has been found no more frequent than after the application of a circular occluding ligature. *Suture* of wounds of veins has been employed with success.

Hæmostatic Forceps.—In case of venous hemorrhage, especially when it is from the deep parts of a wound or cavity, or from the great venous sinuses of the head, it is impossible to apply a ligature; in such a case one or more pairs of hæmostatic forceps may be clamped upon the injured vein or sinus, and, the wound around the forceps being loosely packed with gauze, the forceps are allowed to remain in place for four or five days, at the end of which time they can generally be removed without any recurrence of the bleeding. When forceps are used in this way, care should be taken to protect the projecting parts, so that the patient cannot displace them or do additional injury to the vessel and surrounding parts by forcing the instruments into the tissues. The process of repair in wounded or ligated veins is similar to that which takes place in arteries under the same conditions.

Treatment of Capillary Hemorrhage.—This form of bleeding is usually spontaneously arrested by the exposure of the surface of the wound to the air, but when this does not occur and the amount of blood that escapes is considerable, its control becomes a matter of importance. Capillary bleeding may be arrested by pressure, employed by means of sterilized sponges or gauze pads, which are firmly packed into the wound and allowed to remain for a few minutes. One of the best means of arresting capillary bleeding, however, is the use of hot water or a hot bichloride solution at a temperature of 120° to 150° F. (60° to 65° C.); the water should not be used at a higher temperature than this, as damage to the tissues may result. In capillary bleeding the employment of a five per cent. antipyrin solution also acts well. If hot water fails to control the bleeding, the wound should be firmly packed with strips of sterilized or antiseptic gauze. This dressing is also frequently used to control hemorrhage from mucous cavities, such as the mouth, nose, rectum, vagina, or uterus. The packing should not be removed too soon, but should be allowed to remain for from three to six days, and can at this time be removed without fear of the recurrence of the bleeding.

Treatment of Parenchymatous Hemorrhage.—The amount of blood lost in this variety of hemorrhage is often very great, and its control is sometimes a matter of difficulty. Pressure applied as for the control of capillary hemorrhage, or hot water, may arrest the bleeding; if this fails to check it, the actual cautery or Paquelin's cautery at a dull red heat may be applied with satisfactory results; or in other cases the application of a few deep sutures of catgut or silk, including the tissues, to the depth of the wound, may control the bleeding. In wounds of the liver, spleen, kidney, or tongue, and in tissues whose vascularity is increased by the presence of new growths, bleeding is best arrested by the careful application of sterilized sutures.

Treatment of Secondary Hemorrhage.—Profuse secondary arterial hemorrhage is usually preceded by the occurrence of one or more slight hemorrhages, which may recur at intervals of a few hours or days; the amount of blood lost at these times may be slight, but their occurrence should always excite the suspicion of the surgeon, and he should have the patient carefully watched by a skilled attendant who is competent to act in case the bleeding becomes excessive. Elevation of temperature and a feeling of tension in the wound, caused by effusion of blood around the artery, are symptoms which often precede secondary hemorrhage.

In arteries ligated in their continuity, the bleeding often arises from the distal side of the ligature; this has been accounted for by the facts that the distal clot is less in extent and is slower in forming than the proximal clot, and that the ligature diminishes the vitality of the vessel-walls immediately below the seat of the ligature by obstructing the vasa vasorum, or the obstruction in the capillaries below the seat of the ligature may be greater than that in the anastomosing vessels, and the blood-pressure may therefore be greater in the vessel at the distal than at the proximal side of the ligature.

As soon as it is evident that secondary hemorrhage has occurred, prompt

treatment is demanded. In secondary hemorrhage from a wound, digital or instrumental pressure should be made above and below the wound, and if the bleeding be from a vessel of one of the extremities, an elastic tube should be placed around the limb some distance above the wound, to control it temporarily. The wound should be opened and blood-clots turned out, and it should be enlarged, if necessary, to expose the source of the bleeding, and if it is found that the hemorrhage has arisen from the distal end of the vessel, this should be secured by a ligature applied to the vessel at a point where its walls are in a healthy condition; if the bleeding has arisen from the proximal end of the vessel, this should be ligatured in the same manner with silk or catgut. The wound should next be carefully cleared of blood-clots, and freely irrigated with bichloride solution to render it sterile. If the hemorrhage recurs after a few days, the same procedures should be adopted. If the bleeding again recurs, the surgeon should ligate the artery of supply at some distance above the wound, or, in the case of the extremity, amputate the limb above the source of bleeding; this latter procedure, which seems a most radical one, is attended with better results in cases of repeated secondary hemorrhages than the application of a ligature to the vessel above the source of the hemorrhage, for it removes the infected vessel and surrounding tissues and leaves a clean wound, and at the same time the artery diminishes in size as the demand for blood to the part is lessened by the removal of the limb.

In certain cases of secondary hemorrhage the vessel and surrounding tissues are found in such a sloughing condition that a ligature cannot be made to hold, or the vessel may be injured at a point where a ligature cannot be applied; in such cases the *actual cautery* may be employed, which produces firm temporary closure of the vessel and at the same time sterilizes the wound; if this is not used, firm packing with antiseptic gauze may be resorted to, and the packing, when it is possible, should be covered with an antiseptic dressing held firmly in place by a bandage. The packing should not be disturbed for some days, and then should be carefully removed, and the wound should be repacked in the same manner. These methods of treatment, which are resorted to only when ligatures cannot be applied, are occasionally successful in arresting the bleeding, and should not be lost sight of.

In **secondary venous hemorrhage** firm compression may first be resorted to, and if this fails to arrest the bleeding the wound should be opened and the bleeding vein exposed and ligatured or cauterized, or the hemorrhage may be arrested by firmly packing the wound with antiseptic gauze. At the same time that any of these various procedures is practised for the control of secondary hemorrhage the patient should be most carefully watched by a skilful nurse, and should be placed upon the constitutional treatment which has been previously described as of value in cases of hemorrhage.

Simultaneous Wounds of the Main Artery and the Main Vein of a Limb.—These are most serious injuries, from the risk of gangrene. If the main artery and main vein are both injured, both should be secured by ligatures, and if the collateral circulation is promptly established, gangrene will not occur. In a case of simultaneous wound of the main artery and main vein, if the wound of the vein is not extensive, it

should be closed by a lateral ligature, or if a longitudinal one, it should be closed by sutures to secure permeability at the seat of injury. In a wound of the main vein, ligation of the accompanying artery has been practised, with the idea of diminishing the *vis a tergo* of the circulation. This, however, in practice has not been found to be of advantage. After dressing the wound the limb should be carefully bandaged and elevated.

WOUNDS OF SPECIAL ARTERIES.

Common Carotid Artery.—Wounds of this artery may result from stab or gunshot injury, or from operations upon the neck, and, if not immediately fatal, should be treated by the application of a ligature to the vessel on each side of the wound, and if the vessel has not been completely severed by the wound the division should be completed after the application of the ligatures. If secondary hemorrhage occurs, the ends of the vessel should again be secured by ligatures if possible, or the wound should be firmly packed with iodoform gauze.

Internal Carotid Artery.—Wounds of this vessel should be treated, if possible, by the application of two ligatures, one on each side of the wound, but if the wound is close to the skull, so that its ligation would be impossible, or in cases of secondary hemorrhage from the internal carotid, the common carotid should be tied, and a ligature should also be applied to the external carotid artery, near its origin from the common carotid.

External Carotid Artery.—In case of wound of this artery, ligatures should be placed upon the proximal and distal ends of the divided vessel, and if secondary hemorrhage occurs the ends of the vessel should again be secured by ligatures. Ligation of the common carotid artery will probably arrest the bleeding only temporarily, as the anastomosis of the terminal branches of the external carotids is very free, and it should be practised only when it is impossible to tie the ends of the external carotid in the wound.

Internal Maxillary Artery.—As it is impossible to expose this vessel, the external carotid artery should be ligatured, and if hemorrhage recurs after this procedure it has been recommended that the external carotid upon the opposite side be tied, as the blood reaches the injured vessel by anastomosing vessels from the opposite side of the neck.

Lingual Artery.—The bleeding vessel should be secured in the tongue, if possible, by ligatures or deep sutures; if this cannot be accomplished, the vessel should be ligated in the neck.

Middle Meningeal Artery.—This vessel is usually injured by falls or blows upon the head, or it may be wounded in fracture of the skull. In bleeding from this vessel in compound fractures of the skull the fragments should be removed and the artery exposed and secured by a ligature; if this is impossible, the bleeding should be controlled by packing the wound firmly with iodoform gauze, which should not be disturbed for some days. Trephining may be required for exposure of the vessel in simple fractures of the skull or in cases where the vessel has been ruptured without fracture of the skull.

Vertebral Artery.—Injuries of this artery are very rare, but may result from stab or gunshot wounds. Hemorrhage from this vessel may be

controlled by packing the wound with gauze, or the wound may be enlarged and the vessel exposed and secured by two ligatures.

Subclavian Artery.—This vessel may be injured in stab or gunshot wounds, or by a fragment of a fractured clavicle, and if the wound is extensive the patient will probably die from loss of blood before surgical treatment can be applied. If the patient survives the accident, the wound should be enlarged and the vessel secured by two ligatures. If a traumatic aneurism forms, this should be treated by opening the sac and securing the vessel by ligatures applied on each side of the wound.

Internal Mammary Artery.—Bleeding from this vessel should be arrested by the application of ligatures, which can best be done by a blunt curved needle.

Intercostal Arteries.—Hemorrhage from these vessels can be arrested by enlarging the wound and securing the vessel by two ligatures, even if it is necessary to resect a portion of the rib to expose it, or by introducing a firm compress of gauze into the wound between the ribs.

Axillary Artery.—This vessel may be injured by gunshot and stab wounds, or in removing tumors from the axilla, and has been ruptured in reducing old dislocations of the shoulder. As it is a large one, the bleeding may be so profuse as to be rapidly fatal; temporary control of the hemorrhage may be effected by compressing the third part of the subclavian. The vessel should be exposed by incision, and, if the rupture be a high one, to expose its seat a portion of the pectoral muscle may have to be divided; and when the wound is reached two ligatures should be applied, one to the distal and one to the proximal end.

Brachial, Radial, and Ulnar Arteries.—Wounds of these vessels should be treated by the application of two ligatures to the vessels, one on each side of the wound.

Palmar Arch.—Wounds of the vessels of this arch often give rise to persistent and serious hemorrhage, which should be treated by enlarging the wound and applying two ligatures to the ends of the divided arch. If secondary hemorrhage occurs, an attempt should be made again to secure the bleeding vessels in the wound with ligatures, and if this fails the brachial artery should be ligated at the elbow. The use of pressure by means of a graduated compress applied in the wound may arrest the bleeding temporarily, but is neither so safe nor so efficient as ligation of the bleeding vessels in the wound or ligation of the brachial artery.

Gluteal and Sciatic Arteries.—Wounds of these arteries may arise from stab or gunshot wounds, and the arteries may be injured outside or within the pelvis. In treating hemorrhage from these vessels the wound should be enlarged, and, if it is found to involve the vessel outside of the pelvis, two ligatures should be applied to the injured vessel. If on examination it is found that the bleeding comes from within the pelvis, the most satisfactory method of controlling it consists in ligating the internal iliac artery, from which the wounded vessels arise. Either the intra- or the extra-peritoneal method may be employed in ligating this vessel.

Femoral Artery.—This vessel is frequently injured, and, as the hemorrhage following is very profuse, it may prove rapidly fatal. The bleeding

should be arrested by digital pressure applied to the vessel as it passes over the rim of the pelvis, and two ligatures should be applied, one to each side of the wound, and the division of the artery should be completed if it has not been entirely severed. Secondary hemorrhage should be controlled by again securing the bleeding ends of the vessel in the wound. If bleeding recurs, the external iliac may be tied ; but this procedure is apt to be followed by gangrene of the limb, so that it is generally considered a safer procedure after repeated secondary hemorrhage from the femoral artery to amputate the limb at the seat of the bleeding.

Popliteal and Tibial Arteries.—Hemorrhage from these vessels should be controlled by the application of two ligatures to the wounded vessel, one on each side of the wound, and if the artery has not been completely divided its division should be completed between the ligatures.

INJURIES OF VEINS.

Contusions of veins may result from the same causes that produce a similar condition in arteries, but, as a rule, are much less serious injuries, from the fact that the blood-pressure is much lower and primary and secondary hemorrhage are much less severe. *Thrombosis* of a vein may occur at the seat of injury, but, as the collateral circulation is usually very free between the veins, the return circulation is soon established. Septic infection of a thrombosed vein is, however, a very serious and often fatal complication.

Laceration or Complete Rupture of Veins.—These injuries, if large veins are involved, may cause rapid and excessive loss of blood ; profuse and rapidly fatal hemorrhage may result from wounds of the femoral, iliac, or hepatic veins, as well as from the venous sinuses of the cranium, in which collapse of the walls cannot take place, from the fact that the walls are adherent to the cranial bones. Bleeding from small veins is usually not profuse, and may be spontaneously arrested, or may continue for some time, from the fact that the walls of veins do not contain as much elastic and muscular tissue as those of arteries, so that contraction of the ends of the wounded vein does not take place to favor the arrest of hemorrhage. Extensive extravasation of blood often follows the subcutaneous rupture of comparatively small veins.

Symptoms.—In venous hemorrhage dark-colored blood escapes in a continuous stream, and the bleeding is controlled by pressure applied to the vessel at the distal side of the wound, and is increased by pressure applied at the proximal or cardiac side of the wound.

Treatment.—In punctured or longitudinal wounds of small veins, as the blood-pressure is low, pressure may be relied upon to control the bleeding ; in larger veins, if the wound in the vein be a small one, a lateral ligature should be applied if possible, or the wound may be clamped by hæmostatic forceps, which are allowed to remain in place for three or four days, or the wound may be closed by fine silk or catgut sutures introduced with a fine ordinary sewing-needle. Repair of the wounded vein should take place without obliteration of its lumen. Complete rupture or extensive

wounds require the application of ligatures to the ends of the vein; and although the application of a ligature to the cardiac side of the vein may be necessary only in the case of veins in the axilla and the neck, or where there is very free communication of the veins at a distance from valves, we think it safer to apply two ligatures to the divided vein in any location, if it be a large one.

Entrance of Air into Veins.—This accident, which is a rare one, has occurred when large veins have been opened in operations about the axilla and neck, and has been attended by alarming symptoms and often fatal results. Hare, from experiments upon animals, concludes that death from this accident could result only when enormous quantities of air had been forced into a vein, and is inclined to think that the accident is not likely to happen during operations, and that deaths attributed to this cause are due to other conditions. Be this as it may, careful and competent observers, during operations upon the neck and the axilla, in which large veins were opened, have observed the development of alarming symptoms, or sudden death from cardiac paralysis, which phenomena are difficult of explanation upon any other hypothesis. When a large vein near the heart, such as the axillary, internal jugular, or subclavian, is opened and remains patulous, from mechanical or pathological causes, air is sucked into the vein by the aspirating action of the chest and carried to the right auricle, and death may result from cardiac paralysis, or from syncope if the presence of air in the heart interferes with its action so markedly that sufficient blood is not sent to the brain.

Symptoms.—The entrance of air into the veins is accompanied by a hissing sound, and frothy blood may issue from the vessel. The patient becomes pale, the pupils are dilated, the pulse is feeble and flickering, the respiratory movements are exaggerated, and upon auscultation a churning sound may be heard over the heart. The patient may die rapidly from syncope, or the alarming symptoms may gradually subside, and recovery follow. We have seen a patient during an amputation of the shoulder-joint present these alarming symptoms for a few minutes and eventually recover.

Treatment.—With the possibility of this serious complication in view, in operating upon the neck and the axilla, in the *dangerous area*, as it is termed, care should be taken to secure veins, if possible, on the cardiac side by forceps or ligatures before they are divided; incomplete division of the veins should also be avoided. If, however, the accident occurs, as evidenced by the symptoms presented, the wounded vein should be closed by pressure of the finger until it can be secured by forceps or ligatures; or, if this cannot be accomplished, the wound should be kept filled with normal salt solution or sterilized water, to prevent the further entrance of air. The patient's head should be lowered, to prevent syncope, and the heart should be stimulated by the administration of ammonia and stimulants and the hypodermic use of strychnine and digitalis. The legs and arms should be elevated, and the femoral and axillary vessels may be compressed, to increase the amount of blood sent to the brain. Artificial respiration has been recommended, but the value of this procedure is questionable.

WOUNDS OF SPECIAL VEINS.

Internal Jugular Vein.—A wound of the internal jugular vein is usually quickly fatal from the profuse loss of blood, and the entrance of air into the vein may also influence unfavorably the result of such a wound. The internal jugular vein may be wounded in stab or gunshot wounds of the neck, and is often intentionally or accidentally divided in removing tumors from the neck. In such cases, if possible, the vein should be previously ligatured at two points and then divided between the ligatures. If the wound be a small one, it should be closed by a lateral ligature, the wall of the vein, including the wound, being picked up by hæmostatic forceps and encircled by a sterilized catgut or silk ligature; and while the vessel is being secured firm pressure should be made upon it at the cardiac side of the wound, to prevent the entrance of air into the vein. If the vein is extensively divided or torn, both ends should be secured by ligatures.

Wounds of the Venous Sinuses of the Skull.—These are occasionally seen in cases of injuries of the head with or without fracture of the cranial bones. When associated with simple or compound fracture, the fragments should be removed, and a lateral ligature applied if possible; if the wound be a small one, this may be accomplished, or the wounded portion of the sinus may be grasped with hæmostatic forceps, and these allowed to remain in place for a few days. Trephining, with the removal of a considerable portion of the skull, may be required to expose the wound in the sinus. If the wound is extensive, the bleeding may be arrested by packing the wound firmly with iodoform gauze, which should not be disturbed for some days, and when it is removed a fresh packing should be applied.

Subclavian Vein.—Wounds of this vein may result from stab or gunshot wounds, or may occur in the removal of tumors from the neck, and are attended by a high mortality. If the wound or laceration of the vein is extensive, the hemorrhage is so profuse that a fatal result will probably occur before the bleeding can be arrested. If the wound is a small one, attempts should be made to apply a lateral ligature, or to apply two ligatures to the vein, one on each side of the wound. If these procedures fail, it may be possible to grasp the wounded part of the vein with hæmostatic forceps and thus control the bleeding. The forceps should be allowed to remain in place for a week or more, and the wound should be carefully packed around the forceps with iodoform gauze and covered with a gauze dressing.

Axillary Vein.—This vein has been ruptured in attempts at reduction of old dislocations of the shoulder, and in wounds of the axilla, stab or gunshot, or accidentally in removal of tumors from the axillary space, and has been completely severed in cases of avulsion of the arm at the shoulder-joint. In subcutaneous wounds of the vein, such as occur in reduction of dislocations of the shoulder, a compress should be placed in the axilla, and the arm should be bound to the side; if this controls the bleeding, as shown by the fact that the swelling from effused blood does not increase in size, the arm should be kept in this position for a week or two. If, however, the

swelling increases, the axilla should be opened by an incision, and the wound in the vein exposed and secured by ligatures or clamped with forceps. In small wounds a lateral ligature or sutures should be applied, but if the wound be extensive two ligatures should be applied, one on each side of the wound. In cases where the injury is high up it may be impossible to apply two ligatures; in such cases the distal end may be secured by a ligature and the proximal end grasped by hæmostatic forceps, which are left in place, the wound being packed with iodoform or sterilized gauze.

Iliac Veins.—Wounds of these veins, either the common, the internal, or the external, may be produced by stab or gunshot wounds, or they may be accidentally injured in abdominal operations. Bleeding from these veins is generally so profuse that it is quickly fatal. If, however, the wound is a small one and the blood escapes slowly, the wound in the abdominal walls should be enlarged, and the wound in the vein closed by a lateral ligature if possible, or clamped with hæmostatic forceps; if not, the vein should be ligatured upon each side of the wound.

Femoral Vein.—This vein may be injured in incised, lacerated, or gunshot wounds of the groin, or at other parts of the thigh. In the removal of enlarged glands and malignant tumors from the groin it is also occasionally injured. Small wounds of the femoral vein should be treated by the application of a lateral ligature. More extensive wounds require the application of two ligatures, one on each side of the wound. In cases of wound of the femoral vein, the simultaneous ligature of the femoral artery has been practised in a few cases, with the view of diminishing the *vis a tergo* of the circulation and thus preventing gangrene from venous engorgement. This has been practised, but the results do not seem to justify the procedure, and we are of the opinion that it should not be adopted unless there is at the same time a wound of the femoral artery.

Repair of wounded blood-vessels is considered on page 77.

THROMBOSIS.

This consists in the coagulation of blood in a blood-vessel, the blood-clot remaining at its point of origin. A *thrombus* is the blood-clot which forms in a blood-vessel during life. Thrombosis may involve either arteries or veins, and the occlusion of the vessel by the thrombus may be partial or complete, and is an essential process in the arrest of hemorrhage.

Causes.—When the white blood-corpuscles or the blood-plaques lose their vitality, or are brought into contact with devitalized tissue, fibrin ferment is formed, which produces fibrin and causes the formation of a coagulum or clot by the union of the fibrinogen of the liquor sanguinis with the paraglobulin of the white corpuscles. Coagulation of blood, resulting in the formation of a thrombus, is not due solely to slowing of the blood-current, as was formerly supposed, but requires also roughening of the inner wall of the vessel from injury or septic infection. When these conditions exist, the blood-plaques leave the centre of the stream, and, with the leucocytes, become arrested upon the roughened surface of the vessel. Thrombosis may arise from the application of a ligature, from injuries of the blood-vessels, from pressure upon a vessel by a splint or a bandage, or from

the presence in it of foreign bodies; atheroma of the arteries may also cause thrombosis. Septic processes may give rise to this condition, as well as certain diseases, such as typhoid fever, pneumonia, phlebitis, and arteritis; the affection in these conditions is probably always due to the entrance of pyogenic or specific organisms. A thrombus when once formed at the seat of injury or irritation of a vessel tends to spread, and usually extends to the next large collateral branch. A rapidly formed thrombus consists of a clot made up of fibrin with red and white blood-corpuscles, and constitutes what is known as a *red thrombus*. When, however, the blood is in rapid motion, and a roughened surface of the wall of the vessel is present, or a foreign body is introduced into the vessel, the white corpuscles alone become attached to it, and there results a *white thrombus*. In some cases, after the formation of a white thrombus, the red corpuscles may become entangled in it, and a thrombus composed of red and white corpuscles, which is known as a *mixed thrombus*, results. A thrombus when once formed may undergo organization, calcification, disintegration or red softening, or yellow or infective softening.

Organization.—The process of organization of a thrombus in a vein is similar to that observed in the healing of a ligated artery (page 76). Embryonic and fibrous tissue replacing the blood-clot, the vein may be obliterated, or the channel may be restored to a greater or less extent by the spaces in the clot enlarging and coalescing and communicating with the vein beyond. The clot is then said to be canalized.

Calcification.—Occasionally after thrombosis of veins, especially those which are varicose, small, lime-like bodies are observed to the distal side of the valves, which are known as *phleboliths*, and are composed of phosphate and sulphate of lime and sulphate of potash. These bodies may be free in the channel or may be attached to the vein by a narrow pedicle.

Disintegration, or Red Softening.—A thrombus may soften and be changed into a grayish-red pulp, the process beginning in the centre of the clot, and the softened material being emptied into the circulation and deposited in various organs and tissues; but, as the material is not infective, it produces no symptoms of localized inflammation in the tissues in which it is deposited.

Yellow or Puriform Softening.—When the thrombus becomes infected with septic micro-organisms from the walls of the vein or from the circulation, the softened clot contains broken-down leucocytes and bacteria, and the process which is known as yellow or puriform softening takes place, the clot being converted into a reddish-yellow, creamy pulp. This process is always associated with septic phlebitis. In this variety of softening the broken-down clot passes into the circulation, and particles of the softened clot as infective emboli find their way to the lungs, liver, and other organs, giving rise to metastatic or secondary abscesses. Puriform softening of thrombi is an important factor in pyæmia. The most favorable termination of an infected thrombus is the formation of a localized abscess, which may occur if the infected material is shut off by coagulation.

Symptoms.—The symptoms observed in thrombosis will depend upon the seat of the obstruction. In superficial vessels the position of a clot can

usually be seen and felt; if an artery be involved, the absence of pulse and anæmia of the tissues below the obstruction can generally be observed; in veins, swelling and œdema of the tissues drained by the veins are very marked. When thrombosis involves important organs, impairment of function results in proportion to the amount of the organ involved. Pain in the course of the vessel is a common symptom. Anæsthesia may also be present in the swollen tissues, presenting a form of infiltration anæsthesia.

EMBOLISM.

The process of the passage of a foreign body or blood-clot and its deposit in a different portion of the vascular system is known as embolism. An embolus consists of a detached portion of a thrombus, a globule of fat, a vegetation from the valves of the heart, or a portion of a tumor, which is swept into the circulation and is ultimately arrested in some portion of the arterial or venous system, where it causes plugging of the vessel. Emboli may arise either in the venous or in the arterial system. An embolus is arrested when it reaches a vessel whose diameter is less than its own, and is apt to lodge in a vessel at a point where its diameter very suddenly diminishes—for instance, after a bifurcation. When an embolus lodges it may partially or completely obstruct the circulation in the parts supplied by the obstructed vessel. The results following embolism depend upon the size of the embolus and the site of its arrest, as well as upon whether it is infective or non-infective. A small non-infective embolus may be arrested in a vessel and give rise to no marked symptoms, or may be lodged in the pulmonary artery, giving rise to dyspnœa, hæmoptysis, and a localized pneumonia. On the other hand, the embolus may be arrested in one of the cerebral vessels and cause paralysis or subsequent degenerative changes in the cerebral tissue, or a large embolus may be arrested in the heart and cause sudden death.

Treatment.—In view of the possibility of embolism which may be rapidly fatal or may result in permanent impairment of function, the greatest care should be exercised in every case of thrombosis to prevent this complication. A patient with a thrombosed vein should be kept at rest, and the part should also be kept entirely at rest until sufficient time has elapsed for the organization of the clot, or until it has been absorbed or disintegrated. The detachment of a portion of the clot takes place without warning, often upon some slight exertion. Sudden death from cardiac arrest in these cases has generally occurred in patients who were considered out of danger; therefore the surgeon should stand upon the side of safety by keeping the patient quiet for a period longer than would seem absolutely necessary.

DISEASES OF THE VEINS.

The walls of the veins are thinner than those of the arteries, and are composed of three coats, an inner coat of connective tissue lined with endothelium, a middle coat composed of circular and longitudinal fibres interlaced with involuntary muscular fibres which are much less abundantly developed than in the arteries, and an external fibrous coat composed

largely of white fibrous tissue. Superficial veins in certain localities of the body, notably those of the lower extremity, are provided with valves, which give mechanical support to the column of blood; the deep veins and those of the portal and hemorrhoidal system are without valves.

PHLEBITIS.

This consists in an inflammation of the coats of a vein, which is followed by changes in these structures, and may exist as an acute and as an acute suppurative or septic phlebitis.

Acute Phlebitis.—This consists in an inflammation of the coats of a vein in which there is an effusion of plastic lymph, and may arise from injury, giving rise to a *traumatic phlebitis*, or from a perivascular inflammation, from the presence of a thrombus in a vein, causing *thrombo-phlebitis*, or from gout, giving rise to *gouty phlebitis*. A form of *chronic* plastic phlebitis is also occasionally seen, in which the inflammation spreads slowly along the vein in the direction of its current and the vessel is finally converted into a firm fibrous cord. Plastic phlebitis may terminate in resolution without marked alteration in the lumen of the vessel, or may cause obliteration of the vein at the seat of disease.

Pathology.—In all cases of phlebitis there is observed marked change in the intima; in thrombo-phlebitis the proliferation of the endothelial cells is very active, and they may extend into the thrombus. In cases resulting from injury or extension of inflammation from perivascular structures, the outer and middle coats present softening and cell infiltration and the deposit of plastic lymph; the endothelium is involved to a less degree. Plastic phlebitis presents little tendency to extension, and is usually limited to the portion of vein injured or to the region of the thrombus. Gouty phlebitis is generally symmetrical.

Symptoms.—In plastic phlebitis pain and tenderness, and sometimes discoloration, are noticed over the inflamed vein, and it can be felt as a hard, knotted cord. Œdema of the tissues drained by the vein is very marked; more or less constitutional disturbance, as evidenced by elevation of the temperature and acceleration of the pulse, may be present, but the constitutional disturbance in this form of phlebitis is not so marked as in septic or suppurative phlebitis.

Treatment.—The patient should be put at rest in bed, and the inflamed part should be supported and raised upon a pillow, to favor the return of venous blood. Absolute rest of the part and as little manipulation as possible are the chief indications to be followed, for the greatest danger is from embolism. The tissues over the inflamed vein should be covered by a strip of lint spread with ointment of belladonna and mercury equal parts, and over this should be placed a layer of cotton batting, which may be made to cover the whole limb; a flannel bandage should next be evenly applied to the part, from its lowest extremity to a point some distance above the seat of the disease. This dressing should be allowed to remain for four or five days; subsequent dressings should be made as infrequently as possible, and the greatest care as regards manipulation and movement of the parts should be exercised, on account of the risk of embolism.

The patient's constitutional condition should also receive attention. The use of saline purgatives is often followed by good results, and in gouty cases the regulation of the diet is a matter of great importance. The solid œdema of the lower extremities, which often persists long after the inflammatory symptoms have subsided, is a troublesome feature. Hot douches and gentle friction or massage will generally be of service in relieving this condition, but in many cases the patient will get relief only by the wearing of a well-fitting elastic stocking, the use of which may have to be continued for months.

Septic or Suppurative Phlebitis.—This condition results from infection of the walls of a vein by pyogenic organisms, which may reach the vein from infected perivascular tissues, or by way of the circulation, or by means of an infected embolus which becomes lodged in the vein. This form of phlebitis, which is, fortunately, much less frequent since the importance of asepsis in wound treatment has been fully recognized, is followed by the development of a thrombus at the seat of inflammation, which is itself soon infected. This disease is often noticed in connection with septic wounds, and, as in most cases of septicæmia and pyæmia the infection occurs by means of the veins, this affection bears a very close relation to these diseases.

Pathology.—The walls of the inflamed vein present the appearances common in suppurative inflammation; the infected thrombus becomes softened and purulent, and the broken-down material and the ptomaines resulting enter the circulation; a large abscess may be formed at the seat of the affection, or septic emboli may pass into the circulation, causing metastatic abscesses in other parts of the body; or septicæmia may result from the toxic products which have entered the circulation.

Symptoms.—In suppurative phlebitis of superficial veins the veins become hard and tender on pressure, the surrounding parts are swollen and painful, and œdema is present in the parts drained by the veins. The skin may become red, and soon the presence of an acute abscess can be recognized. The patient at the same time suffers from elevation of temperature and increase in the pulse-rate, the tongue becomes coated, and delirium soon develops. If the abscess is opened or discharges spontaneously, the local and constitutional symptoms may rapidly improve. On the other hand, the above symptoms may be followed by rigors and profuse sweating, and pyæmia may occur. If the disease involves deep-seated veins or the venous sinuses of the cranium, the local symptoms may not be marked, with possibly the exception of œdema, and the occurrence of septicæmia or pyæmia may first call attention to the condition.

Treatment.—Suppurative phlebitis is always a grave affection, and often gives rise to a fatal septicæmia or pyæmia, although a moderate infection may be recovered from, or the amount of infection may be limited by prompt treatment. The prompt removal of the infected material from the vein before the blood has been widely infected offers the patient the best chance of recovery. As soon as the condition is recognized, the inflamed vein should be laid freely open, and the infected clot removed with a curette, the walls of the vein being carefully swabbed with a thirty-grain solution

of chloride of zinc or pure carbolic acid, and the cavity packed with iodoform gauze. Hemorrhage is not usually troublesome, but if this occurs when the vein is opened, a ligature should be applied to a healthy portion of the vein on each side of the infected area, which will serve the double purpose of cutting off the vessel from the circulation and thus preventing septic emboli from entering the circulation, and of controlling the bleeding. Another method consists in ligating the vein above at a point where it is healthy, and subsequently laying it open from this point downward, as well as all branches which are inflamed, and irrigating them freely with an antiseptic solution. If the operation is done promptly, marked improvement, both local and constitutional, is usually quickly observed. If secondary or metastatic abscesses develop in the course of the disease, they should be promptly opened and sterilized. Thrombo-phlebitis of the venous sinuses of the skull is occasionally met with, and the treatment is similar to that just described. A patient suffering with septic or suppurative phlebitis should be given a most nourishing diet, stimulated freely, and given such tonics as quinine, iron, and strychnine in appropriate doses.

VARIX, OR VARICOSE VEINS.

A varix is a permanent pathological dilatation of a vein : veins which are so affected are said to be varicose, and present an enlarged, elongated, tortuous, and knotted condition. The superficial veins of the lower extremity are those most commonly involved, the internal saphenous vein and its branches being affected often (Fig. 264); but the veins of the labia, those of the spermatic cord, and the hemorrhoidal veins, as well as those of the trunk and the upper extremity, may present this condition. We had under our care recently a boy who suffered from vesical calculus, in whom the straining efforts in micturition had caused an extensive varicose condition of the superficial veins of the abdomen.

FIG. 264.

Varicose veins of the leg. (Agnew.)

The deep veins are usually free from the disease, but occasionally the communicating branches between the deep and the superficial veins are involved, and a varix is not infrequently observed at this point.

The disease begins with a slow dilatation of the vein; it is not only enlarged transversely, but is also elongated, and, as the ends of the vein are fixed points, the increase in length causes it to become very tortuous. In other cases dilatation, or increase transversely, is most marked, and elongation or lengthening does not occur to any extent. The coats of the involved veins are markedly thickened, the endothelial coat presents longitudinal striæ, and in long-standing cases atheromatous change or calcification may sometimes be observed; the external coat is also very

much thickened, by reason of connective-tissue infiltration and inflammatory new formation, to which the name *periphlebitis* is attached. The valves are shortened, or often almost disappear, and become insufficient to support the column of blood. The thickening and dilatation may not uniformly involve the whole vein (Fig. 265), so that at points the thinned wall bulges beyond the line of the vessel, giving rise to a condition known as a *venous cyst*.

Fig. 265.

Section of vein showing unequal thickening of walls. (Agnew.)

Causes.—It is generally conceded that any causes which produce increased intravenous pressure tend to the production of varicose veins. The affection is seldom seen in youth, but is very common in middle and advanced age. Women are much more apt to suffer from varicose veins than men; the disease in this class of patients arises from interference with the free return of venous blood from the obstruction offered by the physiological or pathological enlargement of the uterus; the venous obstruction caused by tight garters is also a factor in the production of this lesion. *Constipation* is considered by some authorities a potent cause of this affection, a distended colon causing obstruction of the iliac veins, but the direct relationship between varicose veins and constipation has not been clearly proved, for many cases of the most obstinate constipation are entirely free from this affection. *Occupation* plays an important part in the production of varicose veins: those whose occupation keeps them habitually upon their feet are apt to suffer. There also seems to be an *hereditary* influence which predisposes to this condition; members of the same family through several generations will often suffer from varicose veins. *Gravity* increases the intravenous pressure, and its effects are most marked at the lower end of the blood-column.

The obstruction caused by abdominal tumors and effusions, and diseases of the heart and lungs, in which a feeble circulation removes the *vis a tergo* from the venous blood-current, are well recognized as important factors in the production of varicose veins.

Symptoms.—Extensive varicosity of the veins may exist and yet no marked symptoms be present. Superficial varicose veins are recognized by their tortuous outline and bluish color. Patients who suffer from varicose veins usually complain of a sense of fulness or tension and more or less dull pain in the enlarged veins upon walking or standing; this is quickly relieved if the limb is raised or the patient assumes the horizontal posture. When venous cysts exist, they can be emptied by pressure or by raising the part which contains them. They are often situated near the saphenous opening, and give a distinct impulse upon coughing, so that they have sometimes been mistaken for femoral hernia.

Rupture of Varicose Veins.—One of the most serious symptoms which may arise from varicose veins is hemorrhage, which usually follows a scratch or bruise over a thinned portion of the vein; the bleeding is profuse, and

unless checked may cause a fatal result. In the *treatment* of bleeding from this source, elevation of the part will often arrest the hemorrhage, or permanent control of the bleeding can be secured by elevating the part, and, after sterilizing the small wound and the surrounding skin with bichloride solution, placing over the wound a compress of iodoform gauze or sterilized gauze, which is to be held firmly in place by a bandage, including the limb from the toes to a point some distance above the wound. This should be allowed to remain in place for a week or more, and when removed the wound will usually be found solidly healed. *Thrombosis* is not an infrequent complication in varicose veins, and results from the changes in the inner coats of the veins and the slowing of the blood-current, or from contusion or laceration of the enlarged veins. The treatment of this condition has been described under Phlebitis.

Œdema of the parts surrounding the varicose veins may be marked, and present the characteristics of a solid induration; upon this indurated tissue there frequently develops a *chronic* and *obstinate eczema.*

Ulceration of the indurated tissues surrounding varicose veins may result from a slight wound, or from rupture of a thinned portion of a vein, and if healing is not promptly obtained the ulceration may extend and give rise to frequent bleeding, which eventually may cause a condition of chronic anæmia, or even death. Ulcers occurring in connection with varicose veins are often spoken of as *varicose* ulcers, but the relation of the ulcer to the varicose veins seems rather to be accidental than causal; the diminished nutrition of the indurated tissues caused by the varicose veins predisposes to ulceration after slight traumatism, and also renders the reparative process slow; bleeding arises only when a vein is opened by a wound or by the ulcerative process.

Treatment.—The treatment of varicose veins is both local and constitutional, and consists in removing as far as possible the local causes, as well as the constitutional conditions which predispose to or keep up the condition.

Palliative Treatment.—This aims at the removal of the causes which produce venous obstruction, and in the majority of cases is followed by so much improvement that operative procedures are not required. It consists in the removal of constricting clothing, causing obstruction of the veins, change of occupation, rest in the recumbent posture, and out-door exercise; the condition of the general health, and of the bowels and liver, should also receive attention. If the circulation is at fault, the administration of digitalis and strychnine will often be followed by marked improvement. The use of fluid extract of hamamelis in from fifteen- to twenty-minim doses seems to exert a beneficial effect in varicose veins. The *local treatment* consists in the use of an elastic bandage applied evenly to the part, or a neatly fitting silk elastic stocking, which should be made from careful measurements. These elastic appliances support the part and prevent further dilatation of the veins, besides tending to prevent stagnation of the blood in the veins and diverting it from the superficial veins into the deep veins. In using either the elastic bandage or the elastic stocking, it should be so applied that it will make pressure upon the

limb from the lower part of the foot to a point some distance above the seat of the enlarged veins. (Fig. 266.) In some instances it is necessary to include the limb from the toes to the groin in the stocking or bandage. It is well before applying the elastic stocking or bandage to place a thin cotton stocking upon the limb, and then slip the elastic stocking over this.

Fig. 266.

Elastic stocking applied to the leg.

Operative Treatment.—In cases in which the use of the measures mentioned above and the application of a stocking or bandage are not followed by comfort or relief, or in the case of patients who live a very active life, in whom the wearing of a stocking or bandage is irksome, operative treatment may be resorted to.

In all operations upon veins it is essential that the greatest care should be taken as regards asepsis, for a septic phlebitis may arise from carelessness in this respect, and be followed by most serious consequences. The operations which are now most widely employed for the relief of varicose veins are multiple ligature or excision of a portion of the diseased veins.

Multiple Ligature.—This is accomplished by making a small incision over the enlarged vein, and passing around the vein a sterilized silk or catgut ligature, and tying it securely; the ends of the ligature should be cut short, and the small wound should be closed by a suture. A number of ligatures may be applied in this manner; twenty or thirty may be applied to veins of the leg and thigh at one time. After closing the wounds the limb should be enveloped in an antiseptic dressing and elevated, and the patient should be kept at rest in bed for ten days or two weeks. Very satisfactory obliteration of the veins will often be obtained by this procedure.

Excision.—This very radical method of treating varicose veins is practised when there are tumor-like masses of varicose veins at one or more places, the rest of the limb being healthy, and consists in exposing the enlarged veins by an incision three or four inches in length, and, after dissecting them out, applying proximal and distal ligatures, and excising the portion of the veins between the ligatures. The only bleeding that is likely to arise is that following the division of veins communicating with the deep veins; if such bleeding occurs, the communicating veins should be secured by ligatures. The wounds should be closed by sutures, a sterilized or antiseptic gauze dressing applied, and the limb elevated, and the patient should be kept in bed for ten days or two weeks. The results following this method of treatment are most satisfactory if care is observed to prevent infection of the wound. Trendelenburg's method, which consists in ligating the saphenous vein in Scarpa's triangle, is also a satisfactory operation in the treatment of varicose veins of the lower extremity.

Phlebectases.—These are stellate groups of dilated venules which are often seen upon the lower extremities of adults or upon other parts of the body. Their presence causes no special symptoms, and they produce little

disfigurement. They are sometimes observed in connection with nævi. If for any reason their removal is considered desirable, this may best be accomplished by the use of electrolysis.

ARTERIAL VARIX, CIRSOID ANEURISM, PLEXIFORM ANGIOMA.

These names are applied to irregular vascular tumors caused by a circumscribed dilatation and elongation of one or more arteries. The elongation of the arteries causes them to present a tortuous appearance, and the convoluted vessels are held together by a small amount of connective tissue.

Arterial Varix.—This consists of an elongation and dilatation of a single artery, the vessel presenting the tortuous and pouched appearance of a varicose vein, and also well-defined pulsation. The skin over the dilated vessel becomes thin, and if injured, or if ulceration occurs, serious or fatal hemorrhage may take place. The vessels in which this condition is most frequently found are the occipital, temporal, and posterior auricular arteries.

Cirsoid Aneurism.—This consists of an irregular swelling made up of tortuous vessels, which can be plainly seen under the skin. (Fig. 267.) The skin over the vessels may be thin or thick, and may be pigmented or of a dull bluish color. The tumor may present well-marked or ill-defined pulsation. If the pulsation is forcible, a thrill and bruit may also be present. The pulsation and thrill may sometimes be diminished or arrested by compressing the tortuous arteries or the main artery from which they are derived; but, owing to the fact that the vessels making up the growths are derived from many sources, it is often difficult to arrest the pulsation by pressure.

FIG. 267.

Cirsoid aneurism. (Bruns.)

Plexiform Angioma, or Aneurism by Anastomosis.—When the vascular dilatation involves not only the arteries, but also the capillaries and veins, the condition resulting is known as a plexiform angioma, or aneurism by anastomosis.

Pathology.—In all these varieties of vascular growth the arteries are dilated and present a varicose condition; the walls are much thinned, atrophy of the middle coat being very marked. The disease, which is considered to arise from injury or disease of the vaso-motor nerves, producing a localized paralysis, generally involves the arteries alone, but may also involve the capillaries and veins. The skin covering the vessels may be pigmented, thickened, or thinned; it may ulcerate at points, giving rise to serious hemorrhage.

Cirsoid aneurism may be confounded with *aneurism*, but is distinguished from this affection by the situation of the growth, the superficial pulsation and bruit, the appearance and number of vessels involved, the doughy or spongy feeling, and the difference in pressure effects. When a cirsoid aneurism follows an injury it is likely to be confused with *varicose aneurism*,

as pulsation, bruit, and thrill are present in both affections. The differentiation of these conditions may be made by observing that in cirsoid aneurism the tumor is not so well defined as in varicose aneurism, and that the pulsation, bruit, and thrill are not arrested by compressing a single arterial trunk, as is the case in varicose aneurism. In *aneurismal varix* the pulsation can be arrested by compression of a single arterial trunk.

Treatment.—The treatment of these forms of vascular growths is difficult, and often fails from the fact that the blood-supply is not derived from one distinct vessel, but from numerous vessels. If the disease involves a limited area, the continuous wearing of a metallic shield will protect the part from injury, and may be followed by a cure. If, however, it is increasing, operative treatment should be undertaken, consisting in ligation of the supplying vessels, strangulation of the mass by a ligature, ligation of the main artery of the part, excision of the diseased tissues, or the employment of electrolysis. All methods of operative treatment except the use of the ligature and electrolysis are accompanied by considerable hemorrhage. If hemorrhage can be controlled by elastic constriction by an Esmarch strap or tube, and the disease is not too extensive, excision is the most satisfactory method; the incisions should be made well away from the growth. The application of a number of ligatures to the vessels at the margin of the growth and ligation of the main artery supplying the growth have been attended with only moderate success. The strangulation of the whole mass, if moderate in extent, by one or more ligatures has been employed in some cases with success.

Electrolysis has recently been employed, and the results following its use seem to indicate that it is a safe and reliable method. The needles passed into the growth are attached to the positive pole, and a surface electrode is attached to the negative pole and placed upon the surface of the body. A strong current of one hundred and fifty or two hundred milliamperes is required. The application may have to be repeated a number of times, and, as the operation is painful, the production of anæsthesia is required at each application.

ARTERITIS.

Arteritis is an inflammation of the coats of an artery, and the terms *endarteritis*, *mesarteritis*, and *periarteritis* are used to designate inflammation respectively of the inner, the middle, and the external coat of the vessel. Arteritis may be either acute or chronic. Acute arteritis may exist in several varieties—*acute plastic arteritis*, *suppurative arteritis*, and *embolic arteritis*.

Acute Plastic Arteritis.—This is the condition which develops after wounds or ligation of arteries in which aseptic conditions obtain, and represents a reparative process which can scarcely be classified under the head of a disease. The process has been described under the repair of wounded arteries. This condition gives rise to no marked symptoms and requires no special treatment.

Suppurative Arteritis.—This consists in an acute inflammation of the coats of an artery, the infection arising from the presence of pyogenic organisms. The disease usually begins as a periarteritis, the external coat of the artery being infected by exposure in an unclean wound, by the presence of

a contiguous abscess, or by the application of an infected ligature or instrument. In the case of an artery containing a thrombus the infection may arise from the blood, in which case an endarteritis will be developed which will rapidly involve the remaining coats of the vessel. The process is attended by softening of the coats of the vessel, the exudation of serum, and the migration of leucocytes, and as a result of these changes ulceration or sloughing of the walls of the artery occurs.

Suppurative arteritis is the most common cause of secondary hemorrhage; this complication following wounds or the ligation of arteries was very frequent before the introduction of asepsis in wound treatment. The formation of a blood-clot at the seat of inflammation in the vessel, which in many cases extends up the vessel well beyond the infected area, probably explains the fact that secondary hemorrhage does not occur in all cases of suppurative arteritis. Arteries which have been contused or partially lacerated, if exposed to infection in a wound, are less able to resist this process than uninjured vessels: hence in such cases the greater liability to suppurative arteritis and secondary hemorrhage. The surgeon should bear in mind the possibility of the development of this affection from the presence of abscess in close proximity to large arteries, which should lead him to open and disinfect such abscesses at the earliest possible time. Almost every surgeon has seen deep-seated abscesses of the neck or thigh followed by secondary hemorrhage from the carotid or femoral artery, often with fatal results.

Embolic Arteritis.—This form of arterial inflammation, which, fortunately, is extremely infrequent, results from the lodgement in an artery of an infected embolus, which sets up an infective endarteritis, the intima becoming œdematous and infiltrated with pus-cells, and the infective process extending to the other coats of the vessel, resulting in the formation of an abscess; or the softening effect of the inflammation upon the intima and the other coats may cause them to become dilated by the pressure of blood within the vessel, producing an aneurism. Rupture of an abscess or of an aneurism formed in this manner is usually attended by a fatal result.

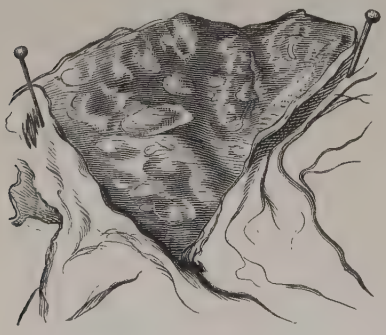
Chronic Arteritis or Endarteritis.—*Atheroma* is an affection of the larger arteries which occurs in advanced age, or at an earlier period in alcoholics, and is characterized by the appearance of areas of degeneration in the coats of the artery, known as atheromatous patches. The disease begins in the deeper layers of the intima, and may involve segments or small patches of the wall of the vessel, consisting in a proliferation of the small flattened cells lying between the layers of fibrous tissue. Hyperplasia of the connective tissue may partially or completely occlude the lumen of the vessel, giving rise to a condition known as *obliterating arteritis.* The atheromatous areas further undergo fatty or calcareous degeneration. *Fatty degeneration* is attended with softening and liquefaction of the tissues and the formation of the so-called *atheromatous abscess*, the contents of which are not pus, but fatty matter and cholesterin: the cavity resulting gives rise to the *atheromatous ulcer.* *Calcareous* degeneration may follow fatty degeneration or occur independently of it, and consists in the deposit of fine granules of

carbonate and phosphate of calcium, which coalesce into flat plates (Fig. 268) or annular bands, constituting laminar or annular calcification. (Fig. 269.) Partial or complete separation of these plates sometimes gives rise to thrombosis or embolism.

Atheromatous degeneration of an artery is an important factor in the causation of aneurism, as the vessel is apt to yield at the situation of an atheromatous ulcer. The atheromatous condition of superficial vessels, such as the radial, the femoral, and the temporal, can often be distinctly felt by the finger.

Treatment.—There is no treatment that can restore to its normal condition an artery in which atheromatous changes have taken place, but a patient presenting such conditions should avoid arterial strains and excesses of all kinds.

Fig. 268.



Atheroma of the arch of the aorta. (Agnew.)

Fig. 269.

Annular calcification of the brachial, radial, and ulnar arteries. (Agnew.)

Syphilitic Arteritis.—This form of arteritis affects the smaller arteries of the brain and viscera; the vessels become thickened, indurated, and narrowed, and as the result of these vascular changes cerebral softening and gummatous degeneration of the tissues occur. The only treatment which is of value in these cases is the use of iodide of potassium, or of this drug combined with mercury. The arterial changes resulting from syphilis are considered by some authorities to be important factors in the production of aneurism.

Tuberculous Arteritis.—In this condition the inner coat of the artery is very much thickened, the other coats present inflammatory changes, and the lumen of the vessel may be much diminished. The condition results from the tubercle bacilli infiltrating the walls of the artery.

ARTERIO-VENOUS ANEURISM.

This affection consists in an abnormal communication between a vein and an artery, and is recognized as existing in two forms, *aneurismal varix* and *varicose aneurism*.

Aneurismal Varix.—This consists in a direct communication between an artery and an adjacent vein, the arterial blood passing freely into the

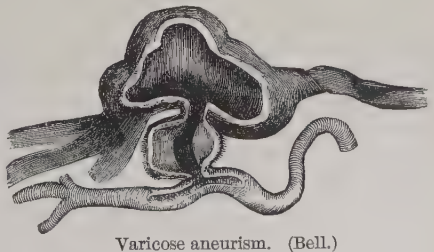
vein. This condition most commonly results from simultaneous wounding of the vein and the artery, resulting from stab or gunshot wounds: very rarely it is congenital. This affection was formerly often seen at the elbow, resulting from puncture of the artery and vein by the lancet in bleeding, when this procedure was very generally practised. It has also been observed in vessels of the head, neck, axilla, abdomen, and thigh. As the pressure of the blood is greater in the artery than in the vein, the blood is forced into the vein, and causes its dilatation near the seat of communication, as well as dilatation of the vein to the distal side of the wound by obstruction of the free return of the venous blood.

Symptoms.—This condition is marked by an ill-defined or oblong compressible tumor with expansile pulsation, thrill, and bruit; the latter is characterized by a peculiar purring or buzzing sound, which closely resembles that produced by a fly confined in a paper bag. The bruit, thrill, and pulsation are transmitted for some distance along the distended veins. If the part containing the varix is raised, the pulsation becomes weaker and the tumor shrinks; if the part is lowered, the tumor increases in size and the pulsation becomes more apparent. If the artery is compressed sufficiently to shut off its current, the pulsation ceases and the tumor disappears. The patient often complains of pain in the tumor and of a sense of numbness in the parts below. If the venous return is much obstructed, the parts below become œdematous.

Treatment.—In many cases the tumor does not increase in size, and causes the patient so little inconvenience that it is necessary only to wear a compress or an elastic bandage over it. If, however, pain is a prominent symptom, or if there is marked obstruction to the return of the venous blood, as shown by œdema and ulceration of the parts below, operative interference is demanded. This consists in the application of two ligatures to the artery, one above and one below the seat of the vascular communication.

Varicose Aneurism.—In this affection there is a communication between an artery and a vein through an interposed aneurismal sac. This form of arterio-venous aneurism results from stab, punctured, or gunshot wounds of an artery and a vein, a circumscribed aneurism forming between the artery and the vein, and communicating with both. A varicose aneurism may develop from an aneurismal varix if the tissues uniting the vessels yield slowly. The veins become dilated and thickened, as in the case of varicose veins. (Fig. 270.)

Fig. 270.



Varicose aneurism. (Bell.)

Symptoms.—The symptoms are those of aneurismal varix, with the addition of those of aneurism. Pulsation, thrill, and a buzzing sound are present, and in addition a soft aneurismal bruit can often be distinguished. If the circulation in the artery is arrested, the vein collapses, and the outline of the aneurism can often be made out as a firm tumor.

Treatment.—This is the same as for aneurism. In suitable locations digital compression upon the proximal side of the tumor, combined with direct pressure over the communication between the aneurism and the vein, should first be tried; this method of treatment has been followed by satisfactory results. If this fails, the limb should be rendered bloodless by Esmarch's bandage, and the vein exposed and tied with a double ligature; the sac being next exposed, its communication with the artery should be located, and two ligatures applied to the artery; after applying the ligatures the sac is removed. The results following ligature of the vessels and the removal of the sac are much more successful under the modern methods of wound treatment than formerly.

TRAUMATIC ANEURISM.

This consists of a subcutaneous collection of arterial blood in the tissues communicating with a wounded artery, and in the strict acceptation of the term is not an aneurism, as none of the coats of the artery enclose or circumscribe the collection.

A traumatic aneurism may be *diffused* or *circumscribed*, and may result from a subcutaneous rupture or from a punctured wound or complete or incomplete division of an artery. It may occur as the result of gunshot wound, the vessel being contused at the time, and sloughing later. It is also seen in connection with open wounds of arteries, where the external wound has healed before the wound in the artery has cicatrized. As the result of the injury to the walls of the artery, blood escapes into the surrounding tissues in greater or lesser quantity, according to the extent of the wound in the vessel; if the wound is an extensive one, or if the artery is completely ruptured, blood in large quantity is poured out in the tissues, and, forcing its way along the different layers of fasciæ and muscles, soon causes marked swelling and tension of the parts; this gives rise to the condition known as *diffused traumatic aneurism*. If, on the other hand, the wound in the artery is a small one, a small amount of blood may escape gradually, and be circumscribed by coagula and the surrounding tissues, which form an adventitious sac; this is known as a *circumscribed traumatic aneurism*.

A *diffused* traumatic aneurism usually increases rapidly in size, and may extend widely through the tissues, causing much swelling, or may reach the surface and rupture, giving rise to fatal hemorrhage, or the tissues surrounding the effused blood may be the seat of acute suppurative inflammation, which gives rise to abscess; when this opens pus is discharged, and this is followed by the escape of clots and free bleeding, which is apt to be fatal unless promptly controlled.

A *circumscribed* traumatic aneurism, as before stated, does not tend to increase rapidly in size, as the sac is firmer and stronger and may undergo spontaneous cure in time, but is liable to present yielding of some portion of the sac, which leads to a rapid enlargement of the aneurism, in which case the conditions are similar to those found in diffused traumatic aneurism.

Symptoms.—A diffused traumatic aneurism usually presents a rapidly growing swelling, with tension of the overlying tissues; there may be feeble or well-marked expansile pulsation and bruit, and a thrill can usually be de-

tected. The pulse in the artery beyond the seat of swelling may be feeble or entirely lost, depending upon the nature of the wound in the artery and the amount of pressure produced by the effused and clotted blood. In diffused traumatic aneurism of the extremities the parts beyond the swelling become œdematous and discolored from the venous obstruction caused by the effused blood. Pain at the seat of the aneurism and numbness in the limb are also marked symptoms. If the condition is not promptly treated, moist gangrene is very apt to occur. In circumscribed traumatic aneurism there is a distinct pulsating tumor; pressure-symptoms are not always present, and the symptoms are those of a sacculated aneurism.

Diagnosis.—In cases of traumatic aneurism the diagnosis is generally not difficult unless suppuration in the tissues around the effused blood occurs, giving rise to the formation of abscess. The diagnosis can usually be easily made if the history of an injury is elicited which was followed by rapid swelling and œdema and numbness and change in the pulse in the vessels of the parts below; but every case should be carefully examined to determine the presence in the swelling of pulsation, bruit, and thrill.

Treatment.—A circumscribed traumatic aneurism, if the swelling does not tend to increase in size, may be cured by elevation and rest of the part, with moderate pressure at the seat of swelling by a compress and bandage. If, however, this fails to produce a cure, compression of the artery upon the proximal side close to the sac may be employed; and if this is unsuccessful, a proximal ligature should be applied to the artery, or excision of the tumor, with ligation of the vessel above and below the aneurism, must be resorted to.

In diffused traumatic aneurism of the extremities, where the circulation can be readily controlled by a tourniquet, as soon as the nature of the arterial lesion is apparent prompt treatment should be instituted, for delay is apt to result in gangrene. The circulation having been controlled by a tourniquet or an elastic strap, the swelling should be freely incised, blood-clots turned out, and the injured vessel sought for. When this is found, if it is completely divided, both ends should be secured by ligatures, or, if incompletely divided, the division should be completed and the ends of the vessel ligatured. The cavity should be cleared of blood-clots, a drainage-tube introduced, and the wound closed. Care must be taken not to injure the vein in exposing and ligating the artery.

If the aneurism arises from an artery in which it is impossible to control the circulation during the operation by pressure or by a tourniquet, such as the common carotid or the iliac, the successful exposure and ligation of the injured vessel is one of the most difficult and anxious operations in surgery. In such cases free incision of the swelling is accompanied by such profuse bleeding that it is apt to be fatal. It is therefore better to make a small incision into the swelling and introduce a finger and feel for the wound in the artery; the warm current of blood may guide the surgeon to the position of the wound. When this is found, bleeding is controlled by pressure with the finger while the external wound is enlarged, and after turning out the coagula the artery is grasped with hæmostatic forceps and ligated, or a ligature is passed around the vessel with an aneurismal needle and

tied. The distal end of the vessel should be secured by a ligature, and the wound then cleansed, drained, and closed.

In cases of diffused traumatic aneurism of the extremities in which gangrene has occurred, amputation at the seat of injury of the artery is the most satisfactory treatment.

ANEURISM.

An aneurism is a circumscribed dilatation of one or more coats of an artery. Arterio-venous aneurisms, or those in which the arterial dilatation is directly or indirectly in communication with a vein, present many points of similarity in symptoms.

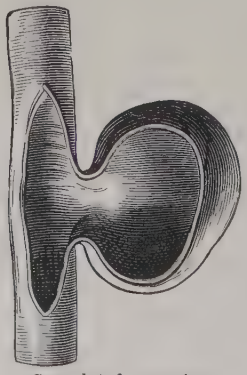
Aneurisms are classified according to their origin, shape, and the structures forming their walls. The first classification includes *idiopathic* or *spontaneous* and *traumatic* aneurisms, the former occurring primarily as the result of disease, although the exciting cause may have been a single severe or more commonly a series of mild traumatisms applied to the affected part, and the latter following a wound of one or more of the coats of the vessel-wall. A second classification is made according to their shape into *tubular* or *fusiform* (sometimes called *ectatic*), *sacculated*, and *dissecting*. A third classification is based upon their structure, including *true* and *false* aneurisms. In the *true* variety all the three coats of the artery are represented in the sac, while in the *false* one or more of the coats are wanting. This is a poor classification, as all stages of gradation, from true to false, are observed in aneurisms, owing to the tendency to degeneration of some of the coats of the sac. Aneurisms are also occasionally classified as *circumscribed* and *diffused*—a division of little importance, the diffused form being merely the condition following the internal rupture of the circumscribed form.

Fig. 271.

Fusiform aneurism. (Agnew.)

Tubular or Fusiform Aneurism.—This is an aneurism in which the dilatation of the artery involves the entire calibre of the vessel; it is in this form that the so-called *true* aneurism is most frequently found, but here also the middle coat very frequently is the seat of degeneration, the muscular fibres sometimes entirely disappearing or becoming widely separated as the disease progresses. (Fig. 271.) It is frequently converted into one of the sacculated variety by a circumscribed weakening of its wall. This form of aneurism is most commonly found in the thoracic and abdominal vessels, and sometimes in the arteries at the base of the brain.

Fig. 272.



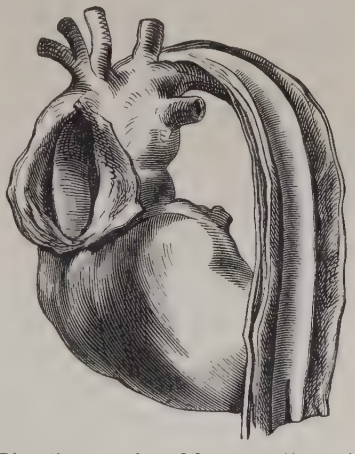
Sacculated aneurism. (Agnew.)

Sacculated Aneurism.—This is an aneurism in which the dilatation is found on one side of the vessel, the opening between the sac and the vessel

being called the mouth. (Fig. 272.) It may originate primarily, or may develop from the tubular form, and varies greatly in size; in the larger ones all distinction as to original coats is finally lost, the sac being composed of fibrous tissue derived from the thickened intima and adventitia incorporated with the surrounding tissues, which are largely converted into fibrous tissue. There is often great destruction of the structures with which it comes in contact, even cartilage and bone undergoing a pressure necrosis, as is frequently seen in the erosion of the sternum and vertebræ occurring in the course of aortic aneurism.

Dissecting Aneurism.—This results from perforation of the intima, as from laceration or rupture of an atheromatous ulcer. There is an extravasation of blood into the vessel-wall, which dissects between its layers for a varying distance, and finally ruptures internally into the lumen of the vessel or externally into the surrounding tissue. It is a rare form of aneurism, generally occurring in the aorta, especially in women, and may exist for years. In cases in which it opens into the artery at its beginning and termination a double tube is present, which may simulate, and has indeed been mistaken for, the rare congenital anomaly of a double aorta. (Fig. 273.) The duplication of the lumen may be present from the arch of the aorta to its bifurcation.

Fig. 273.



Dissecting aneurism of the aorta. (Agnew.)

Causes.—The causes of aneurism are predisposing and exciting. The **predisposing causes** include whatever tends to decrease the strength of the vessel-wall or to increase the strain which it is forced to bear. The most important predisposing cause is atheroma, especially in its earlier stages, when there have already taken place an infiltration and degeneration of the media and adventitia without compensating endarteritis, which develops later. In the later stages, when calcareous changes are present, the decreased elasticity of the vessels causes increased pressure and predisposes to dilatation. All diseases which give rise to atheroma, such as alcoholism, rheumatism, syphilis, and gout, are predisposing causes of aneurism. Rheumatism also gives rise to aneurism through the production of emboli. Individuals are occasionally seen who have a tendency to the development of aneurisms in different parts of the body without apparent cause. These cases of so-called *aneurismal diathesis* are explainable by deficiency in the development of the arterial coats.

Sex.—Aneurism is more common in males than in females, in the proportion of seven to one. This is due to the greater strain on the vessels in males consequent on muscular exertion, and to their more frequent exposure to the diseases producing atheroma.

Age.—Age is a predisposing factor; middle life, a period of considerable activity, with beginning atheroma, is the period at which aneurism is most

frequently developed. Aneurism occurring in childhood and youth is the result of embolism or of a developmental weakness.

Occupation.—Occupations involving severe muscular exertion predispose to aneurism; thus, soldiers and laborers often suffer from this affection.

Country.—Aneurism is usually said to be more common in England and Ireland than elsewhere. Eldridge has recently called attention to the frequency with which it is encountered in European residents in Japan, a fact which he attributes to the wide-spread distribution of syphilis among the earlier residents.

Hypertrophy of the heart, by increasing blood-pressure, may act as a predisposing cause.

The **position** of the vessel is an active predisposing cause, so far as it determines the site of the aneurism. Thus, large vessels situated near the heart, into which the blood is thrown at high pressure, often increased by curves in the vessel itself, as the aorta, innominate, and subclavian, are especially liable to aneurism. It also occurs in those positions in which muscular strains are greatest, as shown by the more frequent occurrence of aneurism in the vessels of the right arm than in those of the left, and where vessels are exposed to traumatism, as in the femoral and popliteal arteries. There is also a disposition to the formation of aneurism at the point of bifurcation of the vessel; for example, at the divisions of the common carotid and the popliteal.

The **exciting causes** of aneurism are severe blows, wounds, or violent exertion; severe concussion of the mediastinal region may give rise to aortic aneurism, and strains of the popliteal artery in conjunction with dilatation of that vessel have especially been noted as causes of popliteal aneurism. A peculiar exciting cause of aneurism occurs in acute rheumatism and ulcerative endocarditis: emboli are liberated, which act either by (1) plugging of the artery, with subsequent dilatation to the cardiac side (*embolic aneurism*), or (2) by carrying micro-organisms, which set up degenerative processes in the vessel-wall (*mycotic aneurism*). The small aneurisms found in tubercular cavities in the lung, rupture of which often causes pulmonary hemorrhage, are the results of tubercular infiltration of the vessels. The same process due to other micro-organisms is sometimes seen in arteries traversing infected wounds.

Pathology.—The best method of classifying aneurisms according to their pathology is that of Thoma, who divides them into aneurisms by *dilatation* and aneurisms by *rupture*. The first class is due to the dilatation of all the coats of the vessel, and embraces the fusiform and a few of the sacculated variety—the so-called *true* aneurisms. It occurs in the early stage of atheroma, and, as has been already stated, the three coats are rarely demonstrable in their entirety in the later stages, the media soon atrophying, and the other coats becoming blended with each other and with the surrounding altered tissues into a typical fibrous aneurismal sac. In the second variety of aneurism, that by rupture, which includes most of the sacculated variety and all of the dissecting aneurisms, the initial lesion is a rupture of the intima or of the intima and media, occurring primarily in the undilated artery or secondarily in the fusiform variety. This rupture may be due to strain

acting upon the slightly thickened intima, or to the rupture of an atheromatous ulcer. If both intima and media be ruptured, as by the bursting of an atheromatous ulcer the edges of which are not firmly glued together, a dissecting aneurism will probably result. If the intima alone, or the intima and elastic coat of the media, be torn, unless prompt healing takes place, there will be left a spot of lessened resistance, which becomes the seat of a gradual yielding of the remaining fibres of the media and adventitia, and a sacculated aneurism results. Where a sacculated aneurism develops from a fusiform one, it is known as a *mixed aneurism.*

Structure.—The wall of a fusiform aneurism consists at first of all the coats of the vessel, which later become blended with one another and with the surrounding structures. In sacculated aneurisms other than the smallest the same condition sooner or later develops; the surrounding nerves, fascia, cartilage, and even bone, with much inflammatory tissue, become involved in the sac. The lining of the sac in most cases consists of two layers of blood-clot: the outer, that in contact with the wall, is a firm, pale, laminated layer of fibrin, increasing in density towards the periphery, and constituting the laminated, fibrinous or *active clot.* It is derived, according to some authorities, from the blood-stream in its passage over the roughened wall of the vessel, which acts as a foreign body and excites clotting, or, according to others, from the quiet blood outside of the main stream, as an ordinary clot, subsequently altered by pressure. Inside of this active layer is a soft, dark red coagulum lining the channel, which is the *passive clot,* so called because of the minor part it probably plays in strengthening and curing the aneurism. The deposition of the laminated clot is nature's method of effecting a cure, and acts by lessening the expansile pressure and strengthening the wall of the aneurism. It occasionally becomes organized by the migration into it of lymph-cells from the sac, and upon its formation several of the methods adopted for the cure of aneurism depend for their success. The tendency to the deposit of a laminated clot is poorly developed in the fusiform variety, and, other things being equal, those aneurisms in which it is present grow more slowly than those in which it is absent.

Symptoms.—These are divided into two classes, subjective and objective.

Subjective Symptoms.—These are mostly the result of pressure; *pain* is usually present when the aneurism reaches any size, and is either a dull ache, perhaps associated with a feeling of weight and numbness in the affected part, or is neuralgic, and is often referred to the distribution of the nerve-trunks pressed upon. Pressure on bone is marked by a severe burning or boring pain. Special symptoms are often due to pressure on important structures, as dysphagia, from pressure on the œsophagus; dyspnœa, from obstruction of the trachea; cough, croupy in nature, and change in the voice, from involvement of the recurrent laryngeal nerve; pressure upon the sympathetic nerve may cause dilatation of the pupils and flushing of the face. In intracranial aneurism a persistent murmur is sometimes complained of, and there may be disturbances of the special senses.

Objective Symptoms.—External aneurism appears as a rounded, perhaps fluctuating, generally non-inflammatory swelling in the course of the

artery. Palpation shows a *pulsation* synchronous with the heart-beat, and different from that of a tumor or an abscess situated over the artery by being expansile in character, due to its distention in all directions by the blood passing through it. Pressure on the artery above diminishes or checks this pulsation and causes a reduction in size. Removal of the pressure causes a return of pulsation as soon as the sac is filled; that is, after one or two heart-beats, and not immediately, as in the case of an overlying tumor. As deposition of clot takes place, pulsation becomes indistinct, or may be altogether lost. *Fluctuation* is usually present early in the case, and the blood can be easily squeezed out; but later, as fibrin forms inside the sac, this symptom disappears. A *thrill* is sometimes felt, but is not constant, as is the case in arterio-venous aneurisms. Auscultation with the stethoscope gives a peculiar sound, called a *bruit*, synchronous with the heart-beat, and either soft and blowing or loud and rasping in nature. It is due to the passage of blood under altered conditions of pressure, and is transmitted along the artery beyond the aneurism. Compression of a normal vessel will often cause it, and it is heard over some vascular malignant tumors, in the latter case not being transmitted. The character of the pulse in the vessel below is altered; a pulse-tracing shows a loss of the impulse and of the dicrotic wave, and a diminution in the force and rapidity of the tidal wave. This is due to the conversion of the intermittent current into a continuous one by the pressure of the blood in the elastic sac. The circulation in the limb beyond often suffers serious changes, due to pressure of the aneurism on the contiguous veins, causing varicosities, œdema, or even gangrene; or these symptoms may occasionally be due to the pressure of the sac upon the vessel from which it springs.

In internal aneurism many of the objective symptoms are wanting, although, if it attains large dimensions, it may become subcutaneous or even rupture externally.

Course and Termination.—The tendency of an aneurism is generally towards an increase in size, the exception being in the case of a few of the fusiform variety. This enlargement is generally more rapid in the sacculated form, and may terminate in several ways—viz., inflammation, rupture, gangrene, syncope, and death by pressure on other organs. Spontaneous cure sometimes takes place, either by the formation of a laminated clot with cessation of growth and disappearance of pulsation followed by contraction, with partial or complete obliteration of the vessel, or by sudden plugging of the artery by a portion of a detached clot or by clot *en masse*, perhaps as the result of inflammation or occlusion of the artery, and with subsequent contraction and obliteration.

Inflammation.—Mild inflammation is a not infrequent transitory symptom, and is marked by slight tenderness and redness. In its severe suppurative form it is an exceedingly dangerous complication. Suppuration may take place either in or around the sac, and is indicated by a lessening of pulsation and bruit, increase of œdema, and loss in distinctness of outline; pain and redness are present in a more marked degree. fever and chills show constitutional infection, and rupture of the abscess results in an escape of chocolate-colored pus, clotted blood, and later in a free arterial hemorrhage.

The artery may have been occluded by the process, and a cure thus be brought about; this, however, is not common, hemorrhage in such cases being a frequent cause of death.

Rupture of the Sac.—Diffused aneurism from this cause is attended by much the same symptoms as mark the onset of inflammation, diminished pulsation, loss of outline, etc., except that the temperature of the part is generally reduced. There is also much greater obstruction of the circulation beyond, gangrene often ensuing from loss of the arterial circulation and the increased venous obstruction. The collection of blood may become circumscribed by the formation of an adventitious sac, and a return of pulsation occur. More commonly suppuration sets in, with external rupture and death from hemorrhage. If rupture takes place into a cavity or on the surface of the body, death is rapid. On mucous surfaces there is generally a prolonged weeping of blood before the final rupture, the opening being of small size; whereas on serous surfaces it is large and stellate, death being correspondingly rapid. Gangrene is usually preceded by venous obstruction, and is therefore nearly always of the moist variety, and is not an uncommon complication in aneurisms of the extremities.

Pressure.—Pressure on the trachea, œsophagus, heart, and phrenic and pneumogastric nerves sometimes causes death. *Syncope* as a cause of death is most frequent in aortic aneurism, and is due to sudden failure of the left ventricle to propel the great quantity of blood in the sac.

Diagnosis.—Numerous cases are on record in which aneurisms have been mistaken for abscesses and opened with fatal results. Every swelling, therefore, in the line of an artery should be carefully examined with a view of excluding aneurism before an operation is attempted. Abscesses and tumors situated over blood-vessels may be mistaken for aneurisms by reason of transmitted pulsation, and certain malignant pulsating tumors, as osteosarcomata and encephaloids, closely simulate aneurism. From a tumor or an abscess over a vessel the diagnosis is made by the expansile pulsation, differing from the up-and-down movement of the former, the pulsation of the tumor disappearing when it is lifted away from the vessel, by the decrease in size when the artery is compressed above, and also on direct pressure, and by the bruit, which may be simulated by a tumor compressing a normal artery. In abscess, signs of inflammation aid in diagnosis. A diffused aneurism with loss of pulsation and beginning inflammation may closely simulate an abscess, but is commonly attended with marked obstruction in the circulation, which, with the history of the case, and perhaps recourse to exploratory puncture, will assist in a correct diagnosis. Auscultation and percussion, with secondary pressure-symptoms and alterations in the pulse, are of especial value in the diagnosis of intrathoracic aneurism. From pulsating tumors with bruit and thrill the diagnosis may be very difficult. They occur in early life and often in other regions than those affected by aneurism, they are not decreased in size by pressure on the artery above, nor are they much altered by direct pressure. They are not so sharply circumscribed, and pulsation and bruit vary in different parts of the tumor, and when of bony origin the bone from which they spring is commonly altered in shape. In the abdominal aorta we often find in neurasthenic females a violent pulsa-

tion or throbbing, which has frequently led to the diagnosis of aneurism ; but the absence of a definite expansile tumor is the all-important diagnostic sign.

Arterio-venous aneurisms present a very loud bruit and a constant thrill, and participation of the veins in both pulsation and bruit.

In most of the fatal accidents depending on mistaken diagnosis failure to use the stethoscope has been, according to Holmes, the principal source of error.

Treatment.—The treatment of aneurism is both medical and surgical.

Medical Treatment.—The medical treatment, commonly known as Tufnell's, after the surgeon who first systematized it, is applicable as an exclusive mode of treatment to internal aneurism, and is used also in conjunction with surgical methods in external aneurism. It is especially useful in the sacculated form of aneurism with a narrow mouth, the object being by absolute rest in bed to diminish the force and number of heart-beats, and by low diet to decrease the volume of the blood and perhaps increase its fibrin-forming constituents. Absolute rest in bed is enforced for eight or ten weeks, during which time only ten ounces of solid food and eight ounces of liquids per day are allowed, according to Tufnell, although a little more latitude in the case of solids would probably be advantageous. Certain drugs are of great value. Opium, lactucarium, and lupulin may be used for restlessness and pain. Iodide of potassium is one of the most important, although its beneficial action, aside from the relief of pain, is not well understood ; from ten- to twenty-grain doses three times a day are indicated. Compound jalap powder and compound rhubarb pill relieve constipation and have a depleting effect. Other drugs are sometimes beneficial, such as aconite or veratrum viride, acetate of lead, and chloride of barium. For local pain, leeching around the aneurism, and belladonna plaster, or an ice-cap, are useful. Bleeding is called for in dyspnœa and venous engorgement from pressure. Patients often grow very restive under this treatment, and refuse to continue it, or if it fails and operative treatment is impossible, a quiet life and avoidance of excitement or exertion should be recommended.

Surgical Treatment.—The methods by which cure is effected by nature are clotting of the contained blood, either (1) slowly, with the formation of laminated clot, or (2) rapidly, *en masse*, as when the distal orifice is plugged by a fragment of clot, or (3) by shutting off the sac from the general circulation, as sometimes happens in suppuration and sloughing. The methods adopted by surgeons also effect a cure in one of these three ways. Those which act by producing a laminated clot are (*a*) slow compression on the proximal side, and (*b*) two forms of ligation—Hunter's (proximal) and Wardrop's (distal). Those causing rapid clotting are (1) rapid compression, (2) distal compression, (3) Brasdor's ligation, (4) flexion, (5) Reid's method, (6), galvano-puncture, (7) manipulation, (8) introduction of foreign bodies, (9) acupuncture. The methods of attacking the sac itself are the old operation (*Antyllian*) and the modern method of excision. Amputation above or below the seat of disease may also be practised.

Compression.—Compression, which is the ordinary non-operative form of treatment, embraces compression of the artery above or below the seat of

the aneurism, direct compression of the sac, and the combination of the two, as in flexion and Reid's method. In cases forbidding systematic compression or operation the limb may be simply bandaged and elevated, the patient being, of course, kept at rest. This, while it may give relief, will effect a cure only in aneurisms of small vessels, like the anterior tibial. *Proximal compression* of the artery at a distance from the seat of the disease is a favorite method, and is generally preferred, where it is practicable, to any other form of treatment. It avoids the necessity for operation, involves no danger of secondary hemorrhage, which, however, is a complication much less feared than formerly, and produces a fair proportion of cures. It is tedious, often painful, and when practised as digital compression demands a number of skilled assistants. It is contra-indicated in rapidly growing aneurisms, aneurisms threatening to burst, diffused aneurisms, and those in which venous obstruction is present. In patients of a nervous and refractory disposition it is unadvisable. It is most useful in aneurisms of the popliteal and brachial arteries. Compression is either digital or instrumental. The former and better method is largely practised in college hospitals, where a number of intelligent assistants can be obtained. In certain arteries, as in the abdominal aorta and the external iliac, instrumental compression alone is practicable. *Digital compression* is practised by first carefully shaving the skin at the selected point, and, while keeping the skin carefully dusted with boric powder or French chalk, pressing the artery firmly against the bone until pulsation in the aneurism is arrested. One assistant compresses the vessel, preferably with the thumb, being relieved at intervals of fifteen minutes, while another keeps constant watch on the aneurism to warn the compressor of any return of pulsation. The pressure must be continuous for from forty-eight to seventy-two hours. Complete occlusion of the vessel is not necessary, the object being to check pulsation and allow a small amount of blood to pass through the sac, which results in the deposit of a laminated clot and final occlusion of the vessel and in the slow development of the collateral circulation. Complete obliteration of the vessel at the seat of aneurism is held by some authors to be necessary to a cure ; but, while this is the object aimed at by most methods, in others, as Wardrop's, a cure may be obtained while a channel for the blood still persists. *Instrumental compression* may be practised in two ways—either as slow compression, a substitute for the digital method, applied in the same manner and according to the same principles, or as rapid compression, as originally suggested by Murray. Slow compression is inferior to digital compression, owing to the difficulty of keeping any instrument accurately adjusted upon the artery. We may employ Lister's or Skey's tourniquets, Carte's compressor, or in the lower extremity Hopkins's modification of Charrière's instrument, which possesses numerous pads, by means of which the seat of compression can be shifted. Opium and the other measures recommended under medical treatment may be used during the compression treatment as indicated. If after two or three days there is no evidence of cessation of pulsation, or if venous congestion shows that there is pressure by the sac or the instruments on the veins, or if there is much pain or restlessness on the part of the patient, this treatment should be discontinued. A compress

may be placed over the artery and the limb bandaged and elevated, or, if not contra-indicated, the limb may be bandaged in the position of flexion. These temporary measures may allow the patient to rest until compression is again bearable: failing this, ligation, or one of the other operative measures, must be resorted to. *Rapid compression*, which is accomplished by temporary complete obliteration of the vessel, effects a cure by causing coagulation *en masse* of the contents of the aneurism. It was first practised for aneurism of the abdominal aorta, and is employed for disease of that vessel and for iliac and femoral aneurisms. It requires a maintenance of anæsthesia for several hours, and is attended by considerable risk of injury to the viscera and the sac, and of peritonitis. While the mortality is high by this method, it must be remembered that it is employed only in those desperate cases in which other treatment is impossible. *Distal compression*, which also aims at causing coagulation *en masse*, is much inferior to the distal ligature, either Wardrop's or Brasdor's, as it permits a speedy dispersal of the soft coagulum after removal of the pressure, time not being given for permanent contraction and obliteration. It also throws great strain upon the sac. It is applicable only to some cases of aneurism of the abdominal aorta or at the root of the neck.

Direct compression of the sac, the old method of treating arterio-venous aneurisms, is still occasionally used as an adjunct to other modes of treatment.

Flexion, which was introduced by Ernest Hart, is a simple procedure, adaptable to popliteal, inguinal, axillary, and brachial aneurisms at the elbow, and consists in flexing the limb and bandaging it in that position. It is fairly successful, especially in combination with other measures, and, although painful, is not dangerous. It is contra-indicated in large aneurisms, in aneurisms communicating with joints, and in cases where there is inflammation of the sac or œdema of the limb.

Reid's Method.—This is applicable only to aneurisms of the extremities, and is preferred by Stimson to any other form of compression where it can be practised. The patient, after a preliminary stage of dieting and administration of potassium iodide, is etherized, and an Esmarch's bandage is evenly and firmly applied from the roots of the digits up to the aneurism, which is either passed over or, when large and rapidly growing, slightly compressed without being emptied, and the bandage firmly applied up to the trunk. If pulsation in the aneurism is not checked, the Esmarch's tube is applied immediately above the bandage. The whole apparatus is allowed to remain about one and a half hours, during which time anæsthesia is kept up. At the end of this time the anæsthetic is discontinued, the bandage and tube are removed, and a Carte's compressor or other instrument is applied to the artery above the aneurism for from twelve to twenty-four hours longer, being gradually removed. By this method a large quantity of blood is confined in the sac and the artery leading to and from it, which undergoes rapid coagulation, the clot extending into the artery being organized, and that in the sac gradually condensing.

The subsequent compression of the vessel is made to prevent the blood-stream from washing away the soft clots before they are firmly contracted.

The uncertainty of this method is its worst feature, only fifty per cent. of cures being recorded and a few deaths. It is practicable only in sacculated aneurisms of the extremities. Its advantages are that it does not lessen the prospects of success by subsequent ligation, a drawback to digital compression, and that it takes a comparatively short space of time. Syncope occasionally follows removal of the bandage, and capillary hemorrhage may take place around the sac; the nerves may be pressed upon, and there is danger of throwing additional strain on the general circulation.

Ligation.—The methods of ligation are four in number. They are classified according to the position of the ligature in relation to the sac, and are known as Hunter's, Anel's, Brasdor's, and Wardrop's.

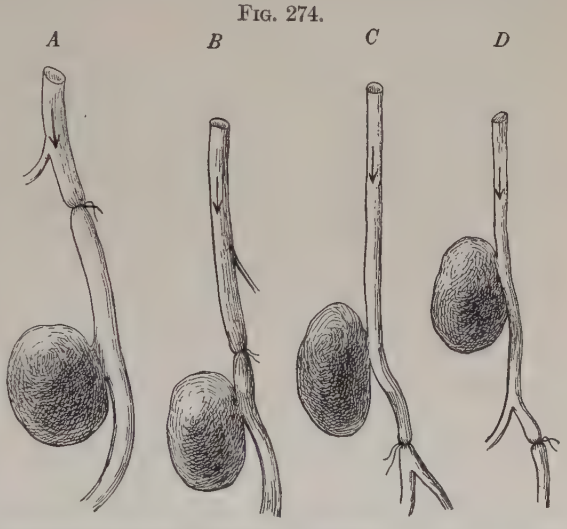


FIG. 274.

Methods of applying ligatures: *A*, Hunter's; *B*, Anel's; *C*, Brasdor's; *D*, Wardrop's.

The Hunterian method of ligation is considered the safest and most satisfactory, and consists in the ligation of the affected vessel at a considerable distance to the cardiac side of the aneurism. (Fig. 274, *A*.) This procedure generally results in an immediate cessation of pulsation in the sac and some shrinkage in its size, with the development of two sets of anastomosing vessels. The *first* develops around the ligature, permitting a gentle stream of blood to flow through the sac, and the deposit of a laminated clot, which fills the aneurism and extends into the artery, occluding it. The occlusion of the artery causes the development of a *second* set of anastomosing vessels around the aneurism; the latter gradually shrinks, and in the course of three or four weeks is usually cured.

Anel's operation differs in the fact that the ligature is applied just above the sac (Fig. 274, *B*), and only one anastomosis is established around both the sac and the ligature. The blood gains admission after ligature only by flowing backward from the origin of the first anastomosing branch below. The advantages offered by the Hunterian method are: (1) the seat of ligature is at a point where the relations are but little disturbed; (2) the sac is in no danger of being injured; (3) coagulation *en masse*, with its subsequent dangers of inflammation and sloughing, is generally avoided. Great importance was formerly attached to the application of the ligature at a distance from the aneurism, where the vessel-walls were considered more likely to be healthy. Recent observations have failed to show any greater liability to increased atheroma near the sac, and, even if it were so, aseptic ligation of an atheromatous vessel is a comparatively safe procedure. This

fact, coupled with the advantage of having but one anastomosis to develop, has led some authors to prefer ligation as near the sac as possible.

Brasdor's operation consists in ligating the artery below the sac (Fig. 274, *C*), thus entirely arresting the circulation through it, and bringing about a cure by occluding the vessel and causing the formation of a clot extending backward from the ligature to the sac, which gradually contracts and becomes obliterated. This method, however, may fail, owing to a partial filling of the sac with a coagulum, when the aneurism may increase in size, or sloughing of the sac may occur. Brasdor's method of ligation is applicable to aneurisms at the beginning of the carotid and subclavian arteries.

Wardrop's method of ligation is also a method of distal ligature, but consists in applying a ligature to one or more of the main branches below the sac (Fig. 274, *D*), not completely stopping the circulation through the sac, and causes a cure of the aneurism by diverting the current of blood from the weaker portions of the vessel, or by an extension backward of the clot from the seat of the ligature. In this method a cure may result without complete obliteration of the circulation through the sac. Wardrop's method has been practised with success in aneurisms at the root of the neck involving the innominate artery and the arch of the aorta.

Complications.—Return of Pulsation.—This may be temporary, disappearing after a few days; its persistence may indicate an *imperfect occlusion* of the vessel by the ligature at the time of operation, or subsequent slipping of the knot, especially if catgut has been employed, and this complication should be treated by the reapplication of the ligature at the same or a lower point. It may also occur as the result of a too free anastomosis around the ligature, which permits a large and rapid current of blood to flow through the sac, interfering with the deposit of a laminated clot and favoring disintegration of that already formed. If pulsation persists, elevation of the limb and compression of the artery and sac may be tried, or, in the case of popliteal aneurism, flexion may be useful. If these fail, ligation nearer the sac is indicated, or excision. In cases where the aneurism remains full of liquid blood, but without pulsation, excision of the sac gives very good results.

Secondary hemorrhage at the point of ligation was formerly a frequent cause of death, and arose from suppuration in combination with non-absorbable ligatures, but is now an infrequent accident.

Suppuration or sloughing of the sac is a very dangerous complication, and may be due to injury of the sac or infection of the wound during the operation, to failure of development of the collateral circulation around the sac, to coagulation *en masse*, or to lack of *supporting* tissue around the sac, as in the axilla and the groin. An attempt may be made to save the limb by waiting until external rupture is threatened, and then incising, first applying a tourniquet if the aneurism still pulsates, turning out the clots, ligating the vessel above and below if it is still pervious, tying all bleeding points, and allowing the wound to granulate, careful watch being kept for the occurrence of secondary hemorrhage. If this fails, and uncontrollable hemorrhage sets in, amputation, if possible, should be performed.

Gangrene.—This dangerous complication generally supervenes from the third to the tenth day, is especially frequent in the lower extremity, and is

usually of the moist variety. After ligation, precautions should be taken to elevate the limb, to wrap it in cotton, and to surround it with hot water bottles, to assist in the preservation of its vitality until the collateral circulation is established. If moist gangrene appears, immediate amputation is the best treatment; at the shoulder-joint in the case of the arm, or at the upper portion of the thigh in the lower extremity. If gangrene of the dry form occurs, amputation may be delayed until the line of separation has formed.

Indications for Ligation in Aneurism.—Ligation is indicated (1) where, although compression is applicable, a scarcity of assistants forbids it; (2) in old, nervous, or intractable patients; (3) where compression is impossible, as in the carotids, the intracranial vessels, and the axillary and femoral arteries near their origin; (4) in diffused or rapidly growing aneurisms, or those accompanied by much œdema; (5) in inflamed aneurisms; (6) where milder methods have resulted in failure.

Contra-indications to Ligation in Aneurism.—(1) Atheroma can no longer be considered a positive contra-indication, since even a much-diseased artery permits of successful aseptic ligation; yet it must be borne in mind as a possible complicating condition. (2) The existence of other aneurisms, especially internal, sometimes contra-indicates the application of a ligature, on account of the danger of throwing increased strain upon the internal circulation. (3) Ligation is contra-indicated in aneurisms where the proximity of large branches affords no room for the formation of a coagulum. (4) In ruptured aneurisms, or in those in which gangrene is threatened, amputation should be preferred to ligation.

Ligatures.—As we expect primary union, there is no objection to silk ligatures being employed, and they are preferred by many on account of the ease and certainty with which they can be sterilized; chromicized catgut and kangaroo tendon ligatures are often employed.

FIG. 275.

Antyllian method.

The Old Operation and Excision.—What is known as the old or Antyllian method was in vogue before Hunter reduced the operation of ligation to a scientific basis, since which time it has been almost entirely superseded by that operation and compression, but it is occasionally employed in dealing with suppuration in cases of diffused or ruptured aneurisms and in sloughing of the sac. The Antyllian operation consists in opening the sac, clearing out the clots, and tying the vessel above and below. (Fig. 275.) The modern method of **excision**, which is a reintroduction in a modified form of the old operation with aseptic methods, has yielded very brilliant results. Thus, a series of twenty cases of major aneurisms of the extremities has been so treated without a death. The circulation is first controlled, if possible, by means of a tourniquet, an incision is made over the aneurism, the affected artery is then ligated above and below the sac, and this is removed by dissection; all the bleeding vessels are tied, and the wound is closed, great attention being given to the prevention of

infection of the wound. This operation has two drawbacks: the dissection is difficult, and there is danger of wounding other important structures. There is no great danger to be feared from ligation of the diseased vessel near the sac, if careful asepsis is practised. The advantages which this operation offers are complete removal of the sac and a consequent radical cure, with the avoidance of a soft clot which may disintegrate and suppurate, as well as avoidance of the pressure of cicatricial tissue on the neighboring nerves. It may be advised in the axilla and groin, in the gluteal region, and in other regions where an aneurism has become diffused and the alternative is amputation. It is well adapted for arterio-venous aneurisms and traumatic aneurisms, and for those cases in which the sac remains full of fluid blood after ligation.

Galvano-puncture, which was first introduced by Phillips in 1838, is practised by the introduction of one or more fine steel needles, trocar-shaped, and well insulated by vulcanite to one-third of an inch of the point, into the sac, and connecting them, one after the other, for five minutes with the positive pole of a galvanic battery, the negative pole being attached to a sponge-covered plate applied to the opposite side of the sac or held in the patient's hand. A current of five or six milliamperes is employed. The positive pole gives a firmer coagulum than the negative, which should never be introduced. The needles are left in an hour or more, to allow the clot to solidify, and are then cautiously withdrawn, and the puncture is sealed with collodion, bleeding being first checked by pressure. There is often an evolution of gas during the process, which distends the sac, and perhaps some œdema around the puncture. Statistics are not very favorable, although amelioration of symptoms may result, as in a case reported by Moullin. The dangers are coagulation *en masse*, sloughing at the point of puncture, and embolism. This procedure may be resorted to in the aorta and the subclavian artery when other means fail.

Manipulation of the sac is a method introduced by Fergusson, and consists in kneading the sac with a view of dislodging a portion of the clot, in the hope that it will occlude the distal orifice. Although occasional cures have been recorded, it is too uncertain and dangerous a measure to be recommended.

Introduction of foreign bodies, or Moore's operation, consists in the introduction of some substance like iron or steel wire, catgut, or horse-hair, with a view of exciting coagulation. The results thus far have not been satisfactory. The best material is iron or steel wire, which should be fine and flexible, only a small piece, carefully sterilized, being introduced at a time through a Southey's canula, the end being buried. Inflammation, sloughing, or rupture of the sac is the usual result.

Acupuncture and Macewen's Operation (Needling).—Acupuncture consists in the introduction of several pairs of fine sterilized steel needles (sometimes gilded) into the aneurism, each pair crossing in the sac, and allowing them to remain in place for several days, until a clot has formed around them. Macewen also introduces a long stiff needle into the sac to the opposite wall, which, vibrating in the blood-current, scratches the wall, or is moved by hand for a few minutes so as to scratch the sac in several

places. The needles are allowed to remain in place for several hours to forty-eight hours. He holds that this procedure is followed by the formation of a white clot. This operation may, if necessary, be repeated at intervals of several weeks, and infection should be carefully guarded against. It is sometimes followed by improvement, but is to be recommended only as a last resort.

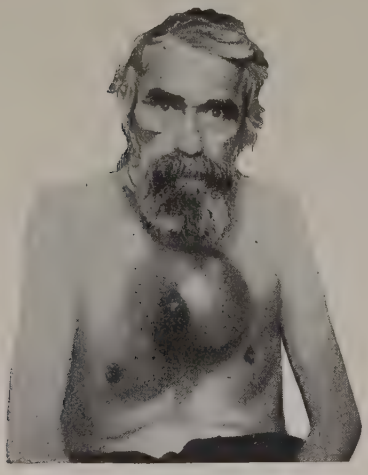
Amputation may be called for in aneurisms of the extremities in the event of failure of other means of cure, or because of complications which develop in the course of the disease. Thus, internal rupture with threatened gangrene, external rupture, erosion of bone or involvement of joints, and suppuration, may, after resisting other treatment, demand removal of the limb. Actual gangrene, of course, leaves no alternative. Secondary hemorrhage at the seat of ligature may be checked at first by religation of the ends of the vessel, but if persistent and evidently due to disease of the vessel-wall it will, in the lower extremity at least, demand amputation. Amputation below the sac is sometimes resorted to in aneurism of the subclavian, and acts by diverting the blood-current, by diminishing the amount of blood passing through the sac, and also, perhaps, where the aneurism is situated close to the seat of amputation, by encouraging the spreading of a clot from the point of ligation of the divided vessel backward into the sac.

TREATMENT OF SPECIAL ANEURISMS.

Aortic Aneurism.—The aorta is the most common seat of aneurism in the body. Aneurism is most frequent at the arch and rarest in the abdominal aorta. Any of the various forms may be present. Aneurism of the arch may grow to a large size without producing severe symptoms, which are mainly due to pressure. There is usually dulness over the tumor; auscultation may be negative, or there may be a systolic murmur, a double murmur, or an accentuation of the second sound. Pulsation is often felt through the chest-walls. If it grows anteriorly it causes bulging and perforation of the ribs, cartilages, and sternum (Fig. 276); growing posteriorly, it erodes the vertebræ and causes compression of the cord; growing upward, it produces pulsation at the root of the neck (Fig. 277); the heart is often displaced downward and to the left. Venous engorgement from pressure on the superior vena cava and its branches is common; inequality of the radial pulses, dyspnœa, cyanosis, and congestion of the lung are often seen. Pain of a boring or burning character is produced by the erosion of bone. Pressure on the nerves causes a neuralgic, lancinating pain. Dysphagia and dyspnœa, cough and hoarseness, are produced by pressure on the œsophagus, the trachea, and the recurrent laryngeal nerve. Pressure upon the phrenic and pneumogastric nerves may cause disturbance in their distribution. Death follows rupture externally or into the pleura, pericardium, œsophagus, or trachea, from pressure on the surrounding structures, and from syncope due to failure of the left ventricle to propel the large amount of blood in the sac. Aneurism of the aorta must be diagnosed from aortic insufficiency, solid tumors, pulsating pleurisy, and the marked aortic pulsation seen in neurotic patients.

Treatment.—Operative treatment is very unpromising, and should not be undertaken until a thorough trial has been given to medical measures. If these fail, we have the choice of several methods, all attended by danger. Simultaneous ligation of the right carotid and right subclavian in disease of the first portion of the arch, and of the left carotid in disease of the second

Fig. 276.



Aortic aneurism bulging anteriorly. (German Hospital Museum.)

Fig. 277.

Aneurism of the arch of the aorta rising into the neck, posterior view. (Agnew.)

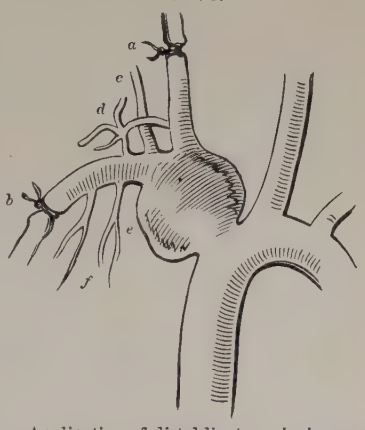
and third portions, sometimes results in temporary improvement. Galvanopuncture may be alleviating, and Macewen's method offers some encouragement, although Macewen deprecates its use in very large thoracic aneurisms. The introduction of foreign bodies has been tried a number of times, with unfavorable results.

Innominate Aneurism.—This aneurism may be confined to the innominate, or the aorta, the subclavian, or the carotid may also be involved. It is usually sacculated. This aneurism presents a tumor over the situation of the innominate, growing forward, eroding the ribs and sternum, and displacing the clavicle, upward over the carotid artery, or backward towards the vertebræ, with alteration of the pulse on the right side in the arm and neck, and with œdema of the same region and the right side of the face, following pressure on the neighboring veins. Dysphagia and dyspnœa may be present, and the neighboring nerves, including the pneumogastric, brachial, and cervical, may suffer from pressure. Like aneurism of the aorta, it is a progressive lesion.

In the *diagnosis* we must exclude aneurism of the arch of the aorta, the first portion of the subclavian, and the carotid at the root of the neck. We rely mainly on the primary point at which the aneurism appears,—that is, at the sternal end of the clavicle and between the heads of the sterno-cleido-mastoid muscle,—the direction in which it grows, the pressure-symptoms, and the pulse in the distal branches of the vessel. Death follows rupture externally or into the pleura, trachea, or œsophagus.

Treatment.—Medical treatment should first be given a careful trial. If it fails, distal ligature of the carotid or of the subclavian, or preferably of both, is the most promising method. (Fig. 278.) A number of cures have been reported by this method. Ashhurst's case of double distal ligature of these vessels for innominate aneurism was in good condition and able to do light work several years after the operation. Macewen's operation has been tried by Thompson and Buchanan, and, although the patient died, the post-mortem revealed beginning coagulation in the sac. Ligation of the innominate itself for aneurism of that vessel or of the subclavian has succeeded in two or three cases, but is one of the most dangerous of surgical operations. Galvano-puncture may be attempted if other means fail.

Fig. 278.



Application of distal ligatures in innominate aneurism: *a*, carotid; *b*, subclavian; *c*, vertebral; *d*, thyroid axis; *e*, internal mammary; *f*, superior intercostal. (Agnew.)

Common Carotid Aneurism.—Any portion of the carotid may be affected by aneurism, but the root of the neck and the bifurcation are the favorite seats, the right being the more frequently diseased, while that portion of the left in the thorax is peculiarly immune. It is almost as frequent in women as in men, being more common in females than any other variety of external aneurism. Besides the ordinary symptoms there is often a disturbance of the cerebral circulation, producing giddiness, tinnitus, etc. Dysphagia, dyspnœa, and cough are usually present, with contraction of the pupil from irritation of the cervical sympathetic, and neuralgia of the cervical nerves. It must be diagnosed from other aneurisms at the root of the neck, from overlying tumors and abscesses, and from pulsating enlargements of the thyroid gland. Rupture externally or into the trachea, œsophagus, or larynx is the usual termination. Cerebral embolism is to be feared, and may cause paralysis and death.

Treatment.—Proximal compression is possible only when there is room between the aneurism and the sterno-clavicular articulation, and is practised by digital pressure against or above the carotid tubercle of the sixth cervical vertebra. It causes faintness and pain, and can be kept up for only a few minutes at a time. Distal ligature is applicable to aneurism at the root of the neck, and in eleven cases gave five deaths (Bolton). Proximal ligature, when there is room, gives a fair hope of success, but, as in all cases of ligation of the carotid, more than one-third of the patients die from cerebral softening. Pulmonary congestion and hypostatic pneumonia may also cause a fatal termination. Simultaneous ligation of both carotids is a uniformly fatal operation. The old operation would be called for by suppuration or rupture of the sac, and has been practised for traumatic aneurism at the root of the neck.

Internal Carotid Aneurism.—The internal carotid may be affected without or within the cranium. The first form, which is rare, protrudes

into the pharynx, and must be diagnosed from tumor and abscess in that locality. It sometimes produces paralysis in the distribution of the pneumogastric, hypoglossal, and glosso-pharyngeal nerves. The intracranial form is usually small, and is often unassociated with symptoms before rupture. It is difficult to diagnose it from other aneurisms at the base of the brain developing in the middle cerebral and basilar arteries. Headache, giddiness, paralysis, and optic neuritis have been observed, and a murmur is sometimes complained of by the patient. The effect of compression of the common carotid on this murmur has been suggested as an aid to diagnosis. Rupture of an aneurism of the internal carotid into the cavernous sinus may be the starting-point of an intra-orbital aneurism. If diagnosed as an affection of the internal carotid or middle cerebral, ligature of the common or internal carotid would be indicated, otherwise medical means must be the limit of treatment.

External Carotid Aneurism.—This should be treated by ligation of that vessel if possible, otherwise the ligature must be applied to the common carotid artery. Excision has been recommended when the branches are the seat of the dilatation.

Orbital Aneurism.—This is associated with protrusion and pulsation of the eyeball, loss of movement, fixation of the pupil, opacity of the media, impairment of vision, and sometimes enlargement and pulsation of the retinal veins. Frequently there appears a pulsating tumor at either angle of the orbit, generally the inner; there are thrill, bruit, and sometimes involvement of the veins of the face. (Fig. 279.) This condition depends upon one of several pathological lesions. Aneurism of the ophthalmic artery may produce exophthalmos, but the involvement of the veins is wanting. This is brought about in one of several ways in the cranium. An aneurism of the internal carotid, as already mentioned, may burst into the cavernous sinus, or a communication between the two may be established by traumatism, as a punctured wound, where they lie in intimate relationship on the floor of the cranium. Rivington has shown this to be the most frequent lesion. The same effect may be produced by an aneurism of the internal carotid or ophthalmic artery pressing on the cavernous sinus, forcing the blood backward into the afferent vessels in the orbit. Congenital cirsoid aneurism and thrombosis of the cavernous sinus are also given as causes of this condition. The other eye may be secondarily affected by means of the communication between the two sinuses. It may result in blindness and death from hemorrhage. Diagnosis must exclude sarcoma of the orbit.

Fig. 279.

Orbital aneurism. (Morton.)

Treatment.—Medical treatment should first be tried, and rest in bed, with iodide of potassium, will sometimes effect a cure. Ligation of the com-

mon or internal carotid is quite successful, and is the operation of choice. Electrolysis has also been employed.

Subclavian Aneurism.—Any of the three portions of the artery may be diseased, the second portion, however, being rarely affected. It is commonest on the right side. It pushes forward the clavicle, or grows upward into the subclavian triangle, or downward and backward against the pleura. It is usually sacculated, and generally ruptures before reaching a great size. There is a delay in the pulse of the corresponding arm, but no change in the carotid pulse unless the innominate is also involved. Compression of the internal jugular and subclavian veins causes œdema in the neck and face in the case of the first vessel, and œdema and even gangrene of the arm in the second. Pain is referred to the arm, and is due to pressure on the neighboring brachial plexus, and on the right side the recurrent laryngeal may be affected as it winds around the first portion of the vessel, producing a brassy cough. Death follows rupture externally or into the pleura or trachea. Spontaneous cure is not very uncommon.

Treatment.—In view of the danger of any operation, medical treatment should first receive a thorough trial. In disease of the first portion proximal compression is impossible, and proximal ligature exceedingly dangerous. Ligation of the first portion of the subclavian has always resulted fatally. Ligation of the innominate has been similarly unsuccessful, except in three or four cases, and is a very formidable operation. When undertaken it is generally advised to tie the carotid and the vertebral at the same time. Distal ligature has never succeeded alone. Amputation at the shoulder-joint with distal ligature of the subclavian is not very satisfactory, but may be demanded. It is possible that with asepsis the future will yield better results for proximal ligation in this situation. Macewen has cured one case of subclavian aneurism by needling. In the third portion proximal compression should first be tried. Ligation to the proximal side in the second or third portion is the preferable operation. Excision, direct compression, and manipulation have been successful in isolated cases. Amputation at the shoulder-joint may here also be finally called for.

Axillary Aneurism.—A history of traumatism frequently precedes the development of axillary aneurism, such as attempts at the reduction of old dislocations of the humerus, and wounds and injuries of the axilla. The development is rapid, corresponding to the lack of support afforded by the tissues of the axillary space. It may grow upward, raising the shoulder, dislocating the clavicle, and appearing in the supraclavicular triangle; inward, eroding the ribs, or outward, abducting the arm, eroding the humerus, and perhaps bursting into the shoulder-joint. It is very liable to inflammation. Characteristic pulse- and pressure-changes are present, as is neuralgia of the branches of the brachial plexus. It has been mistaken for, and must be diagnosed from, abscess in the axilla.

Treatment.—Medical treatment may be tried if operation is impossible, but is not apt to be successful. Compression of the subclavian over the first rib should be tried first, and, as it is painful, anæsthesia may be necessary, with perhaps gentle pressure on the sac. If it fails, ligation of the third portion of the subclavian should be next employed. Excision may be prac-

tised when the aneurism is small and springs from the third portion and presses on the nerves. Reid's method and flexion have also been recommended. Suppuration will call for the old operation or amputation, the latter being also necessary in cases complicated by uncontrollable hemorrhage and gangrene.

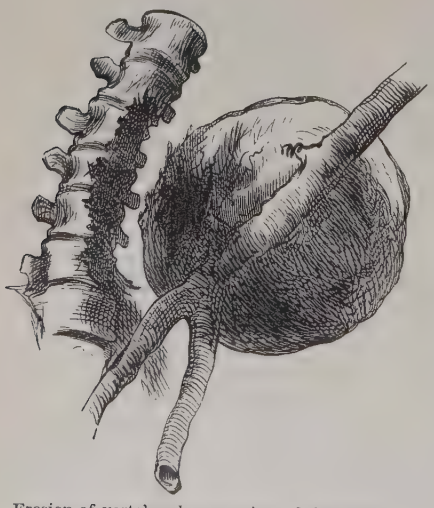
Brachial Aneurism is very rare, with the exception of the traumatic form at the elbow following venesection. It occurred but once in Crisp's group of five hundred and fifty-one cases of aneurism. At the elbow it has a tendency to grow upward along the line of the vessel. Pain from pressure on the neighboring median nerve is a prominent symptom.

Treatment.—Compression is easy, except for the liability of pressing on the branches of the brachial plexus. Proximal ligation of the brachial artery is to be preferred except in aneurisms high up, but, owing to the free anastomosis, it may fail. Excision is suitable for traumatic cases, and may be practised in other forms, especially when there is pressure on the nerves.

Radial and Ulnar Aneurisms.—In these aneurisms in the *forearm* compression of the brachial by flexion at the elbow is suitable. If this fails, the brachial artery should be ligated when the aneurism is deeply seated, or the sac excised when it is superficial. Aneurisms of the palmar arch should be treated by proximal and distal ligature and excision of the sac.

Aneurism of the Abdominal Aorta.—The most common site of its development is near the cœliac axis. It is usually sacculated, and generally takes a forward direction. It is associated with pain in the back, perhaps shooting around the abdominal wall, and gastric symptoms, particularly vomiting, and jaundice also may be present. When it grows backward it erodes the vertebræ, and may open the spinal canal and cause death by compression or inflammation of the cord. (Fig. 280.) Retardation of the femoral pulse is often present. The cœliac axis may be involved. Rupture takes place retroperitoneally into the pleura, or into the peritoneum, or the intestine, particularly the duodenum. Death also follows infarction of the superior mesenteric artery, or obliteration of the lumen of the aorta by clots. It must be diagnosed from overlying tumors and from the pulsating or throbbing aorta found in neurasthenic females. The presence of a distinct pulsating tumor is necessary to a diagnosis. When an aneurism is felt below the umbilicus it usually springs from one of the iliac vessels. Dissecting aneurism is sometimes present in the abdominal aorta.

FIG. 280.



Erosion of vertebræ by aneurism of the abdominal aorta. (Agnew.)

Treatment.—Medical treatment should be carefully tried, although it will often fail. Ligation of the abdominal aorta has been uniformly fatal in the nine cases of aneurism and two cases of hemorrhage in which it has been practised. One patient lived for ten days after the operation. Murray cured a case by rapid compression, and it has since been successful in the hands of others. If the disease is low enough to permit it, this procedure may be successful, although it is attended with danger of injury to the sac, the viscera, and the peritoneum. Macewen practised needling in a case of abdominal aneurism with excellent results, the patient being well after two and a half years' hard labor. In this procedure it is important to ascertain first whether any of the viscera lie between the sac and the abdominal wall. Wire has been introduced in the treatment of this aneurism, with unfavorable results.

Iliac Aneurism.—The external iliac artery is the one most frequently affected. This aneurism may reach a considerable size in the pelvis before being diagnosed. There is often change in the pulse of the corresponding leg, sometimes œdema, or even gangrene. It is frequently of rapid growth. It should be carefully diagnosed from aortic aneurism, tumor, abscess of spinal origin, and pulsating sarcoma springing from the pelvic bones. A close study of the history, the location, the character of pulsation, and the condition of the pulse and circulation in the corresponding limb are the main points to be relied upon in making the diagnosis.

Treatment.—Rapid compression applied to the iliac arteries or the abdominal aorta has been practised with success. Ligation of the common or external iliac furnishes fairly favorable results, and may be practised extraperitoneally or transperitoneally, the latter operation being preferred by some operators on account of the very extensive incision and dissection necessary to the extraperitoneal route.

Gluteal, Sciatic, and Pudic Aneurisms.—The gluteal, sciatic, and pudic arteries are sometimes the seats of aneurism, the first being the vessel most frequently diseased. Most of the cases are traumatic in origin, and owing to their deep situations are not easily recognized, especially as they may be partially intrapelvic. They generally rupture before reaching a very large size. The symptoms are swelling in the buttock, accompanied by pain, referred especially along the great sciatic nerve, and interference with movements of the hip, with the ordinary signs of aneurism. There is frequently a history of traumatism. Diagnosis must exclude abscess and malignant tumor, and may demand the use of the exploring needle. Intrapelvic involvement may be sometimes recognized by rectal or vaginal examination.

Treatment.—Spontaneous aneurism may be treated by proximal ligation, the old operation, or excision. If it cannot be ascertained, as is frequently the case, whether there is extension into the pelvis, ligation of the internal iliac is indicated; for traumatic aneurism the old operation is to be preferred. The aorta or common iliac may be controlled by pressure through the abdominal wall during the operation. Macewen's operation, galvano-puncture, and particularly the injection of perchloride of iron, have been practised, as there is little danger in this situation from embolism.

Femoral Aneurism.—This may develop in the course of the common or the superficial femoral, or the profunda, although it is very rare in the last-mentioned. It is usually sacculated, and is most frequently seen in Scarpa's triangle, where it assumes a globular shape. (Fig. 281.) In Hunter's canal it has a flattened shape, from the limits in which it is confined by the surrounding muscles and fasciæ. There are the usual changes in the pulse below, except when the profunda is the seat of the disease. It may be associated with œdema from venous pressure, with pain from the near relationship of the long saphenous nerve, and with erosion of the pelvis and inflammation of the hip-joint. Death may be caused by rupture or gangrene, which latter accident is less common than in popliteal aneurism, owing to the freer anastomosis.

Fig. 281.

Femoral aneurism. (Deaver.)

Treatment.—Aneurism of the common femoral, which appears in the inguinal region, admits of the same treatment as in case of the external iliac. Compression of the external iliac or the common femoral, if there is room above the sac, may first be tried. Ligation of the common femoral was formerly considered a very dangerous procedure, owing to the number of branches given off near the ligature and the consequent liability to secondary hemorrhage; gangrene was also feared. With asepsis this operation will probably yield much better results. If there is no room to tie the common femoral, the external iliac may be ligated, either extraperitoneally or transperitoneally. If ligation fails, excision of the sac should be practised.

Aneurism of the Superficial Femoral.—In aneurism of this vessel proximal compression yields excellent results, as well as in popliteal aneurism, and should first be given a trial when feasible; otherwise ligation of the superficial femoral when it can be done, or, if not, of the common femoral or external iliac, is the best treatment. Macewen has reported a cure by needling, and excision will be found useful, as it has proved successful in the four cases in which it has been tried. Reid's method is also applicable here.

Aneurism of the profunda should be treated by compression of the common femoral, and, if this fails, ligation of the same vessel or of the external iliac.

Popliteal Aneurism.—The popliteal artery is the most common seat of aneurism next to the arch of the aorta. It is predisposed to by the stretching and traumatism to which the artery is exposed during movements of the knee, by the fact of its bifurcating at the lower margin of the space, and by the lack of supporting tissue around it. It may be bilateral. It is usually sacculated, appearing as a tumor in the popliteal space, causing pain by pressure on the internal popliteal nerve, and sometimes paralysis in the distribution of this nerve. Owing to the very close relationship of the artery and the vein in this space, œdema and gangrene are common. When it takes a forward direction it erodes the femur, excites a synovitis of the

knee-joint, and may perforate the posterior ligament, rupturing into the joint itself. It may extend upward into Hunter's canal or downward into the calf. Rupture may also take place subcutaneously or externally.

Treatment.—Compression is still a favorite mode of treatment, and is applied digitally or instrumentally to the common or superficial femoral. Ligation is often successful, and the superficial femoral at the apex of Scarpa's triangle is the point at which to occlude the vessel, although it may also be practised in Hunter's canal, or even in the upper portion of the popliteal space. Reid's method and flexion probably yield their best results in this situation, and, although uncertain, are not dangerous. Finally, excision has been practised a number of times and very successfully. Bolton gives a mortality of five and two-tenths per cent. from this operation.

Tibial and Plantar Aneurisms.—Aneurisms of the tibial arteries are generally traumatic in origin. In the posterior tibial they may be treated in accordance with the directions already given for popliteal aneurism; in the anterior tibial, compression, ligation, or excision, and in the foot, excision, would be advisable. Aneurisms of the plantar arteries are usually traumatic in origin and arise from punctured or gunshot wounds, but may also arise spontaneously. Kinloch has collected twenty-two cases of spontaneous aneurism of the posterior tibial artery. The treatment of spontaneous aneurism of the tibial arteries consists in the use of distal compression of the femoral artery, and if this fails to produce a cure the aneurism should be exposed by incision and opened, and, after the application of ligatures to the vessels upon either side of the sac, this should be excised. Aneurism of the dorsalis pedis or plantar artery should be treated by ligature of the vessel upon each side, and excision of the sac.

CHAPTER XVII.

LIGATION OF ARTERIES.

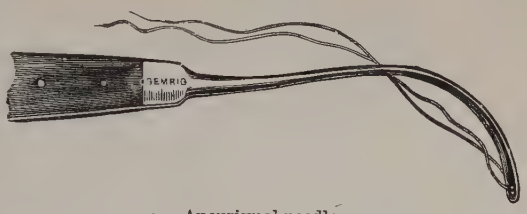
The ligation of an artery in its continuity is an operation which demands skill and exact anatomical knowledge in the operator, and may be required for the control of hemorrhage, the cure of aneurism, and occasionally to arrest the growth of malignant tumors by diminishing their blood-supply.

The instruments required for this operation are scalpels, dissecting forceps, a grooved director, a dry dissector, retractors, and an aneurismal needle or probe. The best material for ligatures is carefully prepared chromicized catgut, kangaroo tendon, or sterilized silk.

In the application of a ligature to an artery in its continuity the surgeon should make his incision in the line which corresponds to the general course of the vessel, and, when possible, a portion of the vessel should be selected for the application of the ligature half an inch or an inch below any large collateral branch. Having selected the position, the surgeon steadies the skin with two fingers and makes an incision of the required length through the skin with a scalpel; the superficial fascia being exposed, it is picked up on a director and divided to an equal length with the incision in the skin; if any large superficial veins come into view, these should be displaced. When the deep fascia has been exposed it should be nicked and divided upon a director. After dividing the deep fascia the surgeon should seek for the intermuscular space which leads down to the vessel, or the muscles, nerves, or tendons which are the guides to the vessel. At this point valuable information may be gained by observing the small arterial branches which come up from the main vessel through the intermuscular spaces, which will often serve as guides to the position of the vessel. The surgeon should next work down in this space, separating the tissues with a director, Allis's dry dissector, the handle of a knife, or the finger, until the sheath of the vessel is exposed, which may be recognized by its communicated pulsation. The artery can generally be recognized by its pulsation, yet sometimes it is so feeble that it does not serve to identify the vessel; arteries have frequently been confounded with tendons, veins, and nerves. Arteries present a pinkish-buff color and are compressible, while tendons are pearly white in color and are much denser in consistence; the deep blue color and thin walls of veins usually distinguish them without difficulty from arteries; a nerve, which resembles an artery in appearance more than a vein or a tendon, may be distinguished from an artery by the fact that it feels like a solid cord, while an artery may be flattened upon pressure, and presents the feeling of two surfaces gliding over each other. When the sheath of the artery has been exposed, it should be picked up with forceps and nicked with the point of a knife applied flatwise; the

incision into the sheath should be only of sufficient size to allow the aneurismal needle to pass through it around the vessel; as the walls of the vessels receive their nutrition from the vessels of the sheath, extensive separation or dissection of the sheath should always be avoided, since otherwise the nutrition of the arteries at the point of ligature may be impaired, and sloughing and secondary hemorrhage result. Only the main arterial trunks possess a distinct sheath, which is replaced in the smaller arteries by a layer of loose cellular tissue.

Fig. 282.



Aneurismal needle.

The wall of the artery being exposed by a small incision in the sheath, an aneurismal needle (Fig. 282) threaded with a ligature is passed around the vessel, and, the ligature being grasped with forceps, the needle is withdrawn; or the needle may be passed around the vessel, and after being threaded with a ligature withdrawn, bringing the ligature after it. In passing the needle care should always be taken to direct it away from important structures, such as veins and nerves, which are in proximity to the artery, as the injury of a vein under such circumstances, or the inclusion of a nerve in the ligature, might give rise to most serious consequences. Before tying the ligature the surgeon should satisfy himself that the ligature when tied will control the circulation in the vessel below its point of application. This may be done by placing the tip of the finger upon the vessel and drawing upon the ends of the ligature, so as to occlude it between the ligature and the finger. Having satisfied himself as to this point, the ligature should be securely tied with the reef-knot, or the surgeon's knot and reef-knot combined, and the ends cut short. Some surgeons in ligating arteries apply two ligatures and divide the vessel between the ligatures. The wound is irrigated and drained if necessary, or may be closed without drainage by the application of a few sutures, and a full antiseptic dressing applied.

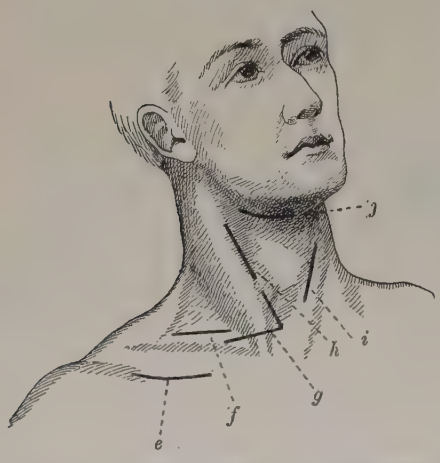
As it is a matter of the first importance that primary union be obtained in wounds made for the ligation of arteries in their continuity, since if infection of the wound occurs sloughing of the vessel may occur and dangerous hemorrhage result, the surgeon should be most careful that every detail is observed which will make and preserve the wound aseptic.

LIGATION OF SPECIAL ARTERIES.

Ligation of the Innominate Artery.—The innominate artery is the largest branch given off from the arch of the aorta, and is about an inch and a half in length; it lies immediately behind the sterno-clavicular articulation, where it divides into the right carotid and right subclavian arteries. By extending the neck the innominate artery can be drawn up and rendered more superficial. It is in relation in front with the innominate veins and the right pneumogastric nerve, on the inner side with the trachea, and on the outer side and behind with the pleura.

Operation.—A V-shaped incision is made, each branch of which is two and a half or three inches in length. One incision lies over the anterior edge of the sterno-cleido-mastoid muscle, the other is parallel to and a little above the clavicle (Fig. 283, *g*); the incisions are carried down to the superficial fascia, and the flap is dissected up. If the anterior jugular vein is met with, it should be displaced or ligatured. The sternal and a portion of the clavicular attachments of the sterno-cleido-mastoid muscle are next divided upon a director; the sterno-thyroid and sterno-hyoid muscles and the middle cervical fascia are next exposed, covered by the thyroid veins. These are pressed aside, and the outer fibres of the sterno-hyoid and sterno-thyroid muscles are divided, the thyroid veins being displaced, and upon tearing through the fascia with a director the common carotid is exposed and traced down to the innominate artery. The most difficult part of the operation is the safe isolation of the artery, which is accomplished by pressing the innominate veins against the sternum with the finger and separating the artery from its sheath about half an inch below its bifurcation. The aneurismal needle should be passed around the vessel from the outer side, so as to avoid the right innominate vein, the pneumogastric nerve, and the pleura.

Fig. 283.



Line of incision for ligation of—*g*, innominate artery; *h*, common carotid artery; *i*, superior thyroid and vertebral arteries; *j*, lingual; *f*, subclavian artery; *e*, axillary artery below the clavicle.

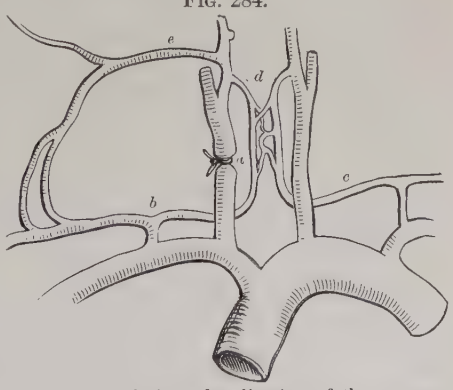
Ligation of the Common Carotid Artery.—The right primitive carotid artery has its origin from the innominate, and the left from the arch of the aorta: the surgical relations, therefore, of the two vessels are not identical in their thoracic portions. The carotid artery on the right side is shorter than the one on the left; the left carotid passes obliquely from its origin into the neck in front of the trachea, œsophagus, and thoracic duct, the left innominate vein, the thymus gland, and the sterno-thyroid and sterno-hyoid muscles being in front; on the right of the vessel lies the innominate artery, and on the left the left subclavian artery and pneumogastric nerve. The surgical anatomy of the carotid arteries after they have entered the neck is identical. The carotid artery, commencing at the sterno-clavicular articulation, passes upward and backward, and becomes more superficial as it ascends the neck. A line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process of the temporal bone represents the general course of the vessel. The carotid artery divides into two branches, the external and the internal carotid, opposite the upper part of the thyroid cartilage, and the vessel is crossed by the omo-hyoid muscle about its middle, opposite the cricoid cartilage. The important structures in proximity to the common carotid

artery are the descendens noni nerve and anterior jugular vein in front of the artery; behind the vessel are the sympathetic and recurrent laryngeal nerves and inferior thyroid artery; internal to the vessel are the trachea, larynx, pharynx, recurrent laryngeal nerve, and the branches of the inferior thyroid artery; and externally are placed the internal jugular vein and pneumogastric nerve in the sheath with the artery. The point of election for the ligation of the common carotid artery is just above the omo-hyoid muscle, about three-quarters of an inch below the bifurcation of the vessel. The common carotid is superficial at this point, and is tied with greater ease, but it occasionally happens that the surgeon is compelled to tie the vessel lower down; when he does so, it may be tied just below the omo-hyoid or a short distance above its origin from the innominate.

Operation.—The patient should be placed in the recumbent position, the shoulders raised and thrown back, the head supported upon a pillow and turned somewhat to the opposite side. The incision for the common carotid artery is three inches in length, along the anterior border of the sterno-cleido-mastoid muscle, the centre of which corresponds with the cricoid cartilage. (Fig. 283, *h*.) The skin, superficial fascia, platysma myoides, and deep fascia are next divided upon the director, when the anterior edge of the sterno-cleido-mastoid muscle is exposed; the interspace between this muscle and the sterno-hyoid and sterno-thyroid muscles is then exposed and the latter muscles displaced inward, when the artery will be found with the jugular vein external to it, and the descendens noni nerve lying upon the sheath. The sheath of the vessels is next picked up and opened, and the artery is carefully separated from it with a director; the artery lies internally, the internal jugular vein externally and somewhat more superficially, and the pneumogastric nerve lies between the two and is more deeply placed. The sympathetic nerve is behind the vessel external to the sheath. The needle should be passed from without inward, care being taken to avoid injury of the internal jugular vein and pneumogastric nerve.

Collateral Circulation.—When the common carotid artery is tied, the circulation is restored to the upper part of the neck and head by inosculation between the inferior thyroid arteries from the thyroid axis and the superior thyroid arteries from the external carotids, and also between the ascending branches of the transversalis colli from the thyroid axis and the princeps cervicis from the occipital. (Fig. 284.) There is also free communication between the internal and the external carotid, both outside of and within the skull.

Fig. 284.



Collateral circulation after ligation of the common carotid artery. (Agnew.)

Ligation of the External Carotid Artery.—The external carotid artery extends from the upper border of the thyroid cartilage upward and

backward to the deep sulcus behind the angle of the jaw opposite the parotid gland, into which it passes, ascending to the neck of the condyle of the lower jaw, where it divides into the internal maxillary and temporal branches. In its course it is in relation with the lingual and facial veins, hypoglossal nerve, and digastric and stylo-hyoid muscles.

Operation.—The patient should be placed in the same position as for the ligation of the common carotid artery. An incision should be made over the inner edge of the sterno-cleido-mastoid muscle from the angle of the jaw to a point corresponding to the middle of the thyroid cartilage (Fig. 285, *c*); having divided the skin, platysma, and cellular tissue, the external jugular vein is drawn aside when encountered; the deep fascia being opened, the facial and lingual veins will be exposed, and should be drawn to one side, or if this is impossible they should be ligated and divided between the ligatures. The artery is next exposed, covered by the hypoglossal nerve and the sterno-hyoid and digastric muscles; the vessel should be carefully isolated from the internal carotid artery and the internal jugular vein, both of which lie along its outer side. The needle should be passed from without inward.

Ligation of the Internal Carotid Artery.—The internal carotid artery is seldom tied except in case of a wound of that vessel, and even in such a case it is probably better, from the great uncertainty attending the true source of such bleeding, to ligate the common carotid artery. The internal carotid artery is ligated by making an incision similar to that for the exposure of the external carotid artery, and the vessel will be found external to the external carotid artery in relation with the superior thyroid, lingual, and facial veins and hypoglossal nerve; in passing the needle the point should be directed away from the internal jugular vein—that is, from without inward.

Ligation of the Superior Thyroid Artery.—The superior thyroid artery is the first branch given off from the external carotid artery, and has its origin from that vessel about one-fourth of an inch below the great horn of the hyoid bone. The vessel passes upward, inward, and downward before entering the thyroid body.

Operation.—An incision is made about three inches in length and along the anterior border of the sterno-cleido-mastoid muscle, starting a little lower down than that for the external carotid artery. (Fig. 283, *i*.) The skin, superficial fascia, platysma, and deep fascia being divided, the cellular tissue in the sulcus between the upper portion of the larynx and the great vessels of the neck should be broken up with a director, and the vessel exposed. The needle should be passed around the vessel from above downward with its point directed towards the thyroid body, in order to avoid injury to the carotid.

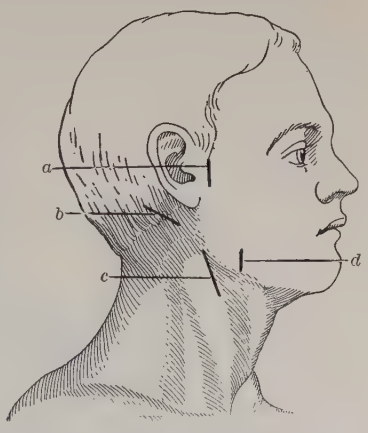
Ligation of the Lingual Artery.—The lingual artery arises from the carotid about an inch above the superior thyroid, nearly opposite the great horn of the hyoid bone, passes under the outer margin of the hyoglossus muscle, and runs parallel with and close to the superior cornu of the hyoid bone.

Operation.—The patient should be placed upon his back, with the head turned a little to the opposite side and well extended, so as to increase the

space between the hyoid bone and the base of the jaw. The position of the great horn of the hyoid bone having been located, a curved incision, two inches in length, with its concavity directed upward, should be made from the anterior edge of the sterno-cleido-mastoid muscle half an inch above the hyoid bone to a point one inch within the median line of the neck. (Fig. 283, *j.*) The skin and platysma being divided, and any superficial veins being displaced, the deep fascia should next be opened upon a director. At this point the submaxillary gland will be exposed; this should be displaced upward with the handle of the knife or the finger, and after dividing the capsule of the gland there will be exposed the shining aponeurosis which holds the digastric tendon to the hyoid bone. The hypoglossal nerve will also be exposed a few lines above the cornu of the bone, running across the hyoglossus muscle forward and upward towards the middle of the jaw. The fibres of the hyoglossus muscle should then be divided for a short distance midway between the hypoglossal nerve and the hyoid bone, and the lingual artery will be exposed. The needle should be passed around the vessel from above downward, in order to avoid the nerve.

Ligation of the Facial Artery.—The facial artery arises from the external carotid a short distance above the lingual artery, and in its course to the face passes under the inferior maxillary bone beneath the stylo-hyoid and digastric muscles and the submaxillary gland, and then passes from the neck to the face over the base of the inferior maxillary bone in front of the masseter muscle. The facial artery is most easily secured at a point where it crosses the lower jaw just in front of the masseter muscle, and is here exposed by an incision one inch in length over the inferior maxillary bone. (Fig. 285, *d.*) The skin, subcutaneous fascia, platysma, and deep fascia having been divided, the vessel will be exposed, and, after having separated it from the vein on its outer side, the needle should be passed between the vein and the artery and carried from without inward.

Fig. 285.



Line of incision for—*a*, temporal artery; *b*, occipital artery; *c*, external carotid artery; *d*, facial artery.

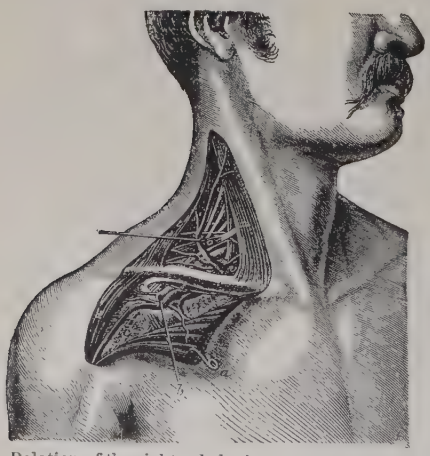
Ligation of the Occipital Artery.—The occipital artery arises from the external carotid artery opposite the facial, and passes backward and upward under the posterior border of the digastric and stylo-hyoid muscles and under the lower portion of the parotid gland, in which position it is crossed by the hypoglossal nerve. The vessel also passes over the internal carotid artery and internal jugular vein and pneumogastric and spinal accessory nerves. The cervical portion of the occipital artery is seldom ligated except for wounds of that vessel. The occipital portion of the artery is the one usually ligated, and is exposed by a horizontal incision two inches in length, starting from a point half an inch below and in front of the apex of the mastoid process, and carried obliquely backward parallel to the border

of this process. (Fig. 285, *b.*) The skin and fascia being divided, the insertion of the sterno-cleido-mastoid muscle should be exposed, which is also divided, and the aponeurosis of the splenius is next exposed. This should be opened and the digastric groove felt for, and when the belly of the digastric muscle is exposed the artery is brought into view by separating the cellular tissue in the anterior angle of the wound with a director.

Ligation of the Temporal Artery.—The temporal artery is the continuation of the external carotid artery. This vessel, after passing through the upper part of the parotid gland, crosses the zygoma posterior to the condyle of the lower jaw and a quarter of an inch in front of the tragus of the ear. The temporal artery is exposed by a vertical incision one inch in length a little in front of the tragus of the ear. (Fig. 285, *a.*) The skin and dense subcutaneous cellular tissue being divided, the artery should be found about a quarter of an inch in front of the ear. The temporal vein accompanies the artery and lies nearer to the ear, and in some cases the auriculo-temporal nerve is also in close relation to the artery. The needle should be passed from behind forward.

Ligation of the Subclavian Artery.—The subclavian artery arises from the innominate artery on the right side and from the arch of the aorta on the left side. The vessel extends from the sterno-clavicular articulation to the lower border of the first rib. The vessel in its course is crossed by the scalenus anticus muscle, and is thereby divided into three surgical regions: the *first* part from its origin to the scalenus anticus muscle; the *second* part beneath or covered by this muscle; and the *third* portion from the external margin of the scalenus anticus muscle to the first rib. (Fig. 286.) The vessel is rarely subjected to operation in either the first or the second part, but is frequently tied in the third part. The left subclavian artery in its first portion is larger and more vertical in its direction than the right subclavian, and is situated more posteriorly; on account of the difficulty in exposing this portion, and the possibility of injuring the thoracic duct, the ligation of this artery in its first portion has seldom been attempted. The incision for the *first* portion of the subclavian artery is the same as that for the innominate (Fig. 283, *g*), and the ligature is passed from the outer side, the pneumogastric and phrenic nerves being pressed inward towards the carotid artery.

Fig. 286.



Relation of the right subclavian artery. (Agnew.)

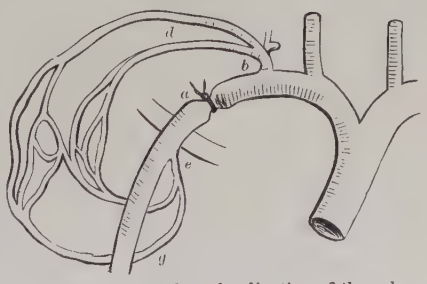
The incision for the *second* portion of the subclavian artery begins an inch external to the sterno-clavicular articulation, half an inch above and parallel to the clavicle, and is three or four inches in length. The steps of the operation are the same as for the ligation of the third portion of the

vessel, and when the scalenus anticus muscle has been exposed it is divided upon a director; care should be taken to avoid injury of the phrenic nerve, which lies upon the anterior aspect of the muscle. The point of election for the ligation of the subclavian artery is the third portion.

Operation.—The shoulders should be elevated by a pillow, the head turned towards the opposite side, and the shoulder corresponding to the side upon which the artery is to be ligated drawn downward. The skin should next be drawn downward over the clavicle, and an incision three or four inches in length, beginning an inch external to the sterno-clavicular articulation, made over the clavicle, and the tissues divided down to the bone. (Fig. 283, *f*.) When this incision has been made the integument is relaxed, and its elasticity will draw the incision about half an inch above the clavicle. The superficial structures having been divided, the external jugular vein must be drawn to one side, or, if this is impossible, it should be divided between ligatures. The deep fascia is next divided upon a director. The posterior belly of the omo-hyoid muscle is found and drawn upward and outward. The outer border of the scalenus anticus is next felt for and followed downward to the tubercle of the first rib. The artery lies against this, between it and the lowest bundle of the brachial plexus. The subclavian vein lies in front of this muscle, but upon a lower plane. The artery is carefully denuded with a director, to avoid injury of the subclavian vein or the pleura, and the needle should be passed from below, care being taken not to include the lowest bundle of the brachial plexus in the ligature. The surgeon should also examine carefully to see that the phrenic nerve, which occasionally passes into the chest over the third portion of the subclavian artery, is not included in the ligature.

Collateral Circulation.—The subclavian artery gives off the vertebral, the internal mammary, and the thyroid axis to the inner side of the point where the scalenus muscle crosses it. When the artery is ligated in its second or third portion, the circulation of the upper extremity is maintained by the blood passing through two branches of the thyroid axis, the suprascapular and transversalis colli arteries, which run across the neck in the direction of the shoulder; branches from these arteries inosculate with vessels from the axillary artery, the subscapular and the dorsalis scapulæ, while the main trunk of the subscapular joins the descending branches from the posterior scapular, which is also derived from the thyroid axis. (Fig. 287.)

Fig. 287.



Collateral circulation after ligation of the subclavian artery. (Agnew.)

Ligation of the Vertebral Artery.—The vertebral artery arises from the subclavian artery and enters the vertebral foramen of the sixth cervical vertebra, passes through similar openings in the vertebræ above, and upon reaching the upper surface of the atlas turns backward around its articular process and enters the cranium through the occipital foramen.

Operation.—An incision from three to three and a half inches in length, parallel with the anterior edge of the sterno-cleido-mastoid muscle, ending an inch above the clavicle, should be made. (Fig. 283, *i.*) The anterior edge of the sterno-cleido-mastoid being exposed, the middle cervical fascia is divided; the carotid artery and the jugular vein are exposed and drawn inward. The gap between the longus colli and scalenus anticus muscles is next felt for, about an inch below the carotid tubercle; the fascia covering it is torn through and the muscles are separated, when the vertebral vein comes into view. This vein being held aside, the vertebral artery should then be exposed and the ligature passed around it.

Ligation of the Inferior Thyroid Artery.—This vessel is a branch of the thyroid axis, and reaches the thyroid body by passing beneath the sheath of the carotid artery and internal jugular vein. The incision for exposure of the inferior thyroid is the same as that for the vertebral artery. (Fig. 283, *i.*) The anterior edge of the sterno-cleido-mastoid muscle having been exposed, it is drawn outward; the middle cervical fascia is next divided, and the carotid artery and internal jugular vein are drawn outward with a retractor. The head being slightly flexed, the surgeon feels for the carotid tubercle and then separates the cellular tissue with a director, when the artery should be found below the carotid tubercle. The needle should be passed between the artery and the vein.

Ligation of the Internal Mammary Artery.—The internal mammary artery is a branch of the first part of the subclavian, which passes downward beneath the clavicle and descends along the inner surface of the anterior wall of the chest external to the pleura, accompanied by its veins, and rests upon the costal cartilages a little external to the margin of the sternum.

The internal mammary artery may be ligated by making a vertical incision two and a half inches in length, commencing at the lower border of the clavicle, and carried parallel with and three lines external to the sternum. The skin and superficial fascia being divided, the fibres of the pectoralis major are exposed; these should be divided, as well as the external intercostal aponeurosis and the muscular fibres of the internal intercostal muscle; the fasciculi of the latter muscle should be raised and divided upon a director, when the vessel will be exposed. The internal mammary artery is not often ligated below the fourth intercostal space.

Ligation of the Axillary Artery.—The axillary artery extends from the middle of the clavicle to the insertion of the teres major into the humerus; the axillary vein lies upon the inner side and in front of the artery. The axillary artery may be ligated either in its upper portion just below the clavicle, or in its lower portion in the axilla.

Ligation of the Axillary Artery below the Clavicle.—The arm being drawn off from the side, in order to render apparent the fissure between the two portions of the pectoralis major muscle, an oblique incision is made over this depression, three inches in length, commencing half an inch from the sterno-clavicular articulation. (Fig. 283, *e.*) Having divided the skin and fascia, the intermuscular space which leads upward towards the clavicle should be opened and its sides separated with a director and the

fingers. The fibres of the pectoralis major being separated, the costo-coracoid membrane is torn through with a director, care being taken not to injure the cephalic vein at the outer portion of the wound; the pectoralis minor is next seen, and, after separating the cellular tissue with a director, the axillary vein is exposed crossing from the upper edge of the muscle to the clavicle; the vein almost completely covers the artery, which is exposed by drawing the vein inward. The needle is passed around the artery from within outward.

Ligation of the Axillary Artery in the Axilla.—The patient being placed in the recumbent position and the arm drawn off from the side, an incision two and a half inches long, starting at the upper point of the axilla and carried down the arm at the edge of the coraco-brachialis muscle, is

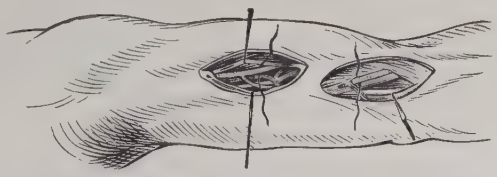
FIG. 288.

Line of the axillary artery in the axilla. (Agnew.)

made. (Fig. 288.) The skin and superficial fascia having been incised, the deep fascia is picked up upon a director and divided, when the coraco-brachialis muscle will be exposed; this should be held aside by a retractor, and the operator working his way inward should first expose the median nerve, next the musculo-cutaneous nerve, and then the axillary artery with the axillary vein on the inner side; the ulnar and internal cutaneous nerves also lie to the inner side of the artery. After the vessel has been isolated, the needle should be passed between the artery and the vein and its point conducted towards the coraco-brachialis muscle, care being taken to avoid the median and musculo-cutaneous nerves.

Ligation of the Brachial Artery.—The brachial artery extends from the tendon of the teres major muscle along the inner edge of the coraco-brachialis and biceps muscles to about half an inch below the bend of the elbow-joint, at which point it divides into the radial and ulnar arteries. The brachial artery may be tied in its upper or middle third or at the bend of the elbow.

FIG. 289.



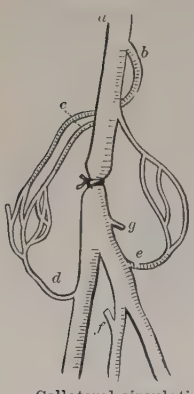
Ligation of the brachial artery at the middle third and at the bend of the elbow. (Agnew.)

Operation.—In ligating the brachial artery in the middle of the arm, an incision three inches long is made on a line corresponding to the inner edge of the biceps muscle (Fig. 289); the skin and cellular tissue are

divided, care being taken not to injure the basilic vein, which should be drawn posteriorly; the deep fascia is next cut through and the fibres of the biceps muscle are exposed; this muscle should be drawn forward, and the sheath of the vessel enclosing the artery and veins is exposed. The median nerve is pressed aside, and, the sheath having been opened, the artery is separated from its veins, and the needle is passed from the median nerve around the vessel. In ligating the brachial artery the occasional high division of the vessel should be borne in mind.

Ligation of the Brachial Artery at the Bend of the Elbow.—In ligating the brachial artery at the bend of the elbow the surgeon should make an incision along the inner edge of the tendon of the biceps muscle, two inches in length. (Fig. 289.) The skin and superficial fascia having been opened, the bicipital aponeurosis is exposed; this being divided, the artery will be found immediately below, the median nerve being some distance to the inner side. After isolating the veins, the needle should be passed around the vessel from within outward.

Fig. 290.

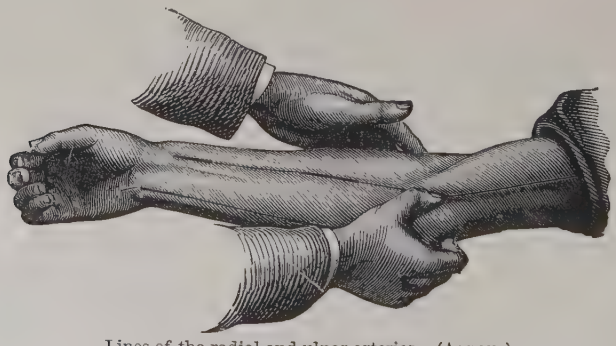


Collateral circulation after ligation of the brachial artery in its lower third. (Agnew.)

Collateral Circulation.—After ligation of the brachial artery the circulation of the parts below is carried on through the superior and inferior profunda, or through the anastomotica magna, which inosculates with recurrent branches from the radial, ulnar, and interosseous arteries. (Fig. 290.)

Ligation of the Radial Artery.—The radial artery extends in a straight line from a point half an inch below the centre of the fold of the elbow to the inner side of the styloid process of the radius. (Fig. 291.) The radial artery may be tied at its upper, middle, or lower third, or at the root of the thumb.

Fig. 291.



Lines of the radial and ulnar arteries. (Agnew.)

Ligation of the Radial Artery at the Upper Third of the Forearm.—In ligating the radial artery at this point, an incision two and a half inches in length, on a line drawn from the middle of the bend of the elbow to the ulnar side of the styloid process of the radius, is made; it should begin one and a half inches below the bend of the elbow. (Fig. 292.) The

skin and superficial fascia are divided, the superficial veins being avoided, and the deep fascia is exposed. When the edge of the supinator longus muscle is recognized its aponeurosis is divided along its ulnar side and the fibres of the pronator radii teres muscle are exposed; the vessel lies in the interspace between these muscles, surrounded by adipose tissue, and after being exposed the veins should be isolated and the needle passed from without inward. The radial nerve lies so far external to the artery that it is not often exposed in this operation.

Fig. 292.

Ligation of the radial artery at the upper and lower thirds and of the ulnar artery at the lower third. (Agnew.)

Ligation of the Radial Artery at the Middle Third of the Forearm.—An incision two inches in length, following the same line as that for the ligation of the upper third of the artery, should be made, and having divided the skin and the superficial and deep fasciæ, the artery is found in the interspace between the flexor carpi radialis on the inner side and the supinator longus on the outer side. The radial nerve at this point of the arm is in close relation to the vessel on the radial side, and the needle should be passed around the artery from without inward.

Ligation of the Radial Artery at the Lower Third of the Forearm.—An incision two inches in length, following the same line as that for the ligation of the upper third of the artery, is made one inch above the wrist. (Fig. 292.) The skin, superficial fascia, and deep fascia having been divided, the artery will be found between the tendon of the flexor carpi radialis on the inner side and the tendon of the supinator longus on the outer side; the veins being separated, the needle may be passed in either direction.

Ligation of the Ulnar Artery.—The ulnar artery descends along the inner side of the forearm between the flexor carpi ulnaris muscle on the inside and the flexor sublimis digitorum on the outside. The artery rests upon the flexor profundus digitorum muscle, and has the ulnar nerve to the inner side. The ulnar artery is tied at the junction of the upper and middle thirds of the forearm and at the lower third.

Ligation of the Ulnar Artery at the Junction of the Upper and Middle Thirds of the Forearm.—An incision three inches in length should be made, starting four inches below the internal condyle of the humerus, on a line passing from this point to the outer border of the pisiform bone. Having divided the skin and the superficial and deep fasciæ, the interspace between the flexor carpi ulnaris and the flexor sublimis digitorum muscles will be exposed. Entering this space and raising the flexor sublimis digitorum and working transversely across the arm, the artery will be found resting upon the deep flexor, with the ulnar nerve to the ulnar side. The needle should be passed from the nerve around the artery.

Ligation of the Ulnar Artery in the Lower Third of the Forearm.—An incision two inches in length should be made a little to the radial side of the tendon of the flexor carpi ulnaris, ending an inch above

the wrist. The skin, superficial fascia, and deep fascia being divided, the artery will be exposed, with its accompanying veins, between the tendons of the flexor carpi ulnaris and the flexor sublimis digitorum, the ulnar nerve being to the ulnar side of the vessel. (Fig. 292.) The needle should be passed from within outward, to avoid the nerve.

Ligation of the Superficial Palmar Arch.—The skin, the palmaris brevis muscle, and the palmar fascia cover the vessel, and beneath it lie the divisions of the median and ulnar nerves, as well as the tendons of the flexor muscles of the fingers. The Esmarch bandage should be applied, so as to control hemorrhage and afford the operator a satisfactory view of the parts. Ligation of the palmar arch is usually required to control hemorrhage from wounds of the arch, and both ends of the divided arch should be secured by ligatures.

Ligation of the Deep Palmar Arch.—The deep palmar arch is formed by the radial artery and a branch from the ulnar artery, and lies upon the interosseous muscles. It is covered by the flexor tendons of the fingers and the flexor brevis pollicis. The wound should be enlarged, and both ends of the divided arch should be secured, care being taken to avoid injury to the deep structures of the palm.

Ligation of an Intercostal Artery.—Ligation of the intercostal arteries may be required in penetrating or non-penetrating wounds of the chest. The intercostal arteries arise from the posterior part of the aorta on each side, and each artery divides into an anterior and a posterior branch. The intercostal artery runs in a groove along the lower border of the rib, where it may be secured by separating it from the rib, or it may be necessary to excise a portion of the rib before it can be satisfactorily exposed.

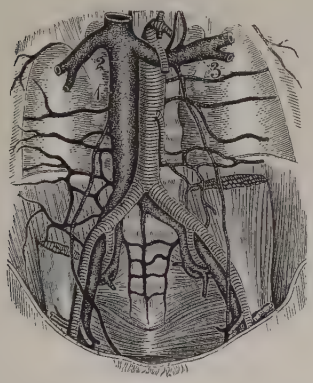
Ligation of the Abdominal Aorta.—The abdominal aorta may be exposed by an incision in the linea alba from a point three inches above the umbilicus to a point three inches below it. (Fig. 294.) The superficial structures having been divided, the peritoneum is opened, the intestines are pressed aside, and the aorta is exposed, covered by the peritoneum with the filaments of the sympathetic nerve resting upon it, and with the vena cava to the right side. The peritoneum being torn through with a director, the needle should be passed from right to left around the vessel. After securing the ligature the ends should be cut short, and the external wound should be closed as in the ordinary laparotomy wound. The abdominal aorta may also be exposed along the anterior border of the quadratus lumborum muscle from the last rib to the crest of the ilium. The skin, fasciæ, lumbar muscle, and fascia transversalis having been divided, the wound should be held open with retractors, so that the retroperitoneal space shall be exposed and the aorta brought into view. The vessel being separated from the vena cava and the nerves, the needle is passed around it and the ligature is applied.

Ligation of the Common Iliac Artery.—The abdominal aorta divides into the two common iliac arteries on the left side of the body of the fourth lumbar vertebra. The common iliac arteries are about two inches in length; the right vessel, in consequence of its having to pass over the body of the fifth lumbar vertebra, is longer than the left. The right iliac artery is covered in front by the peritoneum and the ileum, and at its termination

by the ureter; the primitive iliac veins are placed behind, and on its outer side are the inferior vena cava and the right iliac vein. The left iliac artery is covered anteriorly by the peritoneum and the rectum and the superior hemorrhoidal artery, and at its termination by the ureter; the left common iliac vein is on the inner side and also behind the artery. (Fig. 293.)

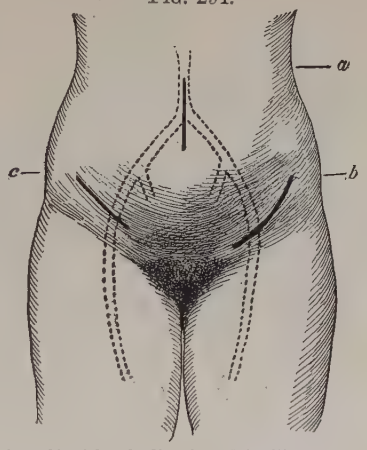
Operation.—The incision for the ligation of the common iliac artery is from four to six inches in length, beginning half an inch above the middle of Poupart's ligament, and is carried outward and curved upward after passing the anterior superior spine of the ileum. (Fig. 294, *b*.) The skin, superficial fascia, and aponeurosis of the external oblique muscle being divided, the fibres of the internal oblique and transversalis muscles are raised upon a director and divided, and the transversalis fascia is exposed. This is opened at the lower part of the wound, and the finger is introduced and the peritoneum pressed back. The opening in the transversalis fascia is next enlarged, and the peritoneum is carefully drawn inward and upward with the fingers towards the inner edge of the wound. The surgeon next feels for the external iliac artery, and passes the finger along this until the common iliac artery is reached. The loose cellular tissue in which it is embedded is separated, and the needle is passed from within outward to avoid the common iliac vein, which on the left side lies on the inner side of the artery and on the right side lies behind the artery. The ureter generally remains attached to the peritoneum; if not, it is seen crossing the bifurcation of the common iliac artery with the genito-crural nerve, and care should be taken to avoid injury to these structures in passing the needle.

Fig. 293.



Relation of the iliac arteries and veins.

Fig. 294.



Line of incision for ligation of the iliac arteries: *a* and *b*, common iliac; *c*, external iliac.

Transperitoneal Method.—The common, external, or internal iliac artery may also be exposed through an abdominal incision three inches in length in the linea alba over the artery, opening the peritoneal cavity,—the transperitoneal incision. (Fig. 294, *a*.) The vessel being exposed and ligated, the ends of the ligature are cut short, and the external wound is closed. In practising this method of ligation the Trendelenburg position will be found most useful. This method of ligating the iliac arteries has

recently been employed in a number of cases with good results, and possesses the advantage that the exposure of the vessels is very free and there is little danger of injury to the veins.

Ligation of the External Iliac Artery.—The external iliac artery extends from the sacro-iliac junction, along the inner margin of the psoas muscle, to Poupart's ligament. At its upper part the external iliac vein is situated behind, and below it is to the inner side of the vessel. The vessel is exposed by an incision three or four inches in length, half an inch above Poupart's ligament, made at first parallel to it, and then curved upward. (Fig. 294, *c*.) Having divided the tissues of the abdominal wall, the peritoneum is exposed, and should be pushed upward and inward in the same manner as for the exposure of the common iliac artery. (Fig. 295.) The external iliac artery lies at the inner border of the psoas muscle, and the vein is on its inner side; the anterior crural nerve covered by the iliac fascia is on the outer side; the genito-crural nerve passes obliquely across the artery. The needle should be passed from within outward.

Fig. 295.

Ligation of the external iliac and femoral arteries. (Agnew.)

Ligation of the Internal Iliac Artery.—The internal iliac artery leaves the common iliac artery at the sacro-iliac junction. The psoas magnus muscle is on the outer side of the vessel. The internal iliac vein and the lumbo-sacral nerve lie behind, and the peritoneum and ureter are in front of the artery. In ligating this artery the incision is the same as for the external iliac artery. The peritoneum being exposed, it is pushed upward and inward, and the internal iliac artery is exposed. The vessel is carefully isolated from the vein which lies behind and on the inner side, and the needle is passed from within outward.

Collateral Circulation.—After ligation of the iliac vessels the blood finds its way to the limb below by the ilio-lumbar and obturator branches from the internal iliac, anastomosing with the lumbar arteries from the aorta and with the internal circumflex from the profunda femoris. The circumflex iliac, from the external iliac, also communicates with the lumbar arteries.

Ligation of the Gluteal Artery.—The gluteal artery emerges from the pelvis by the great sacro-sciatic foramen, above the pyriformis muscle. (Fig. 296.) The gluteal artery may be tied through an incision three or four inches in length, extending from the posterior superior spinous process of the ilium to a point midway between the tuber ischii and the great trochanter. The skin and fascia having been divided, the fibres of the gluteus maximus muscle are separated and held apart and the deep fascia is divided, and the artery should then be sought for above the pyriformis muscle at the upper

border of the great sacro-sciatic notch; it is accompanied by a large nerve and by veins, injury to either of which structures should be avoided in exposing the artery and passing the needle.

Ligation of the Sciatic and the Internal Pudic Artery.—These arteries are exposed by an incision three or four inches in length, a little lower than that employed for the exposure of the gluteal artery. The skin, superficial fascia, deep fascia, and fibres of the gluteus maximus having been divided, the vessels should be exposed as they leave the great sciatic notch at the lower edge of the pyriformis muscle. The internal pudic artery reenters the pelvis through the lesser sciatic notch, lying on the inner side of the sciatic artery during its passage over the spine of the ischium. The vessel should be isolated, and the needle passed so as to avoid injury of the veins.

Fig. 296.

Relations of the gluteal, sciatic, and pudic arteries. (Agnew.)

Ligation of the Femoral Artery.—The femoral artery occupies the inner and anterior portion of the thigh; it is crossed by the sartorius muscle, and is thus divided into two unequal portions. The portion above the sartorius muscle occupies Scarpa's triangle. After leaving Scarpa's triangle the artery enters an aponeurotic canal formed between the adductor magnus and vastus internus muscles (Hunter's canal), after which it perforates the adductor and enters the popliteal space. The femoral vein is at first to the inner side of the artery, then passes behind the artery, and near the apex of Scarpa's triangle is to its outer side. The anterior crural nerve is situated some distance to the outer side of the artery. In Hunter's canal the artery is covered by the long saphenous vein, and is in close relation to the internal saphenous nerve. The general course of the femoral artery in the thigh may be indicated by a line drawn from a point midway between the anterior superior spinous process of the ilium and the symphysis pubis to the tuberosity of the internal condyle of the femur. The femoral artery may be tied just below Poupart's ligament, at the apex of Scarpa's triangle, or in Hunter's canal.

Ligation of the Femoral Artery below Poupart's Ligament.—An incision should be made, beginning midway between the anterior superior spinous process of the ilium and the symphysis pubis, one-fourth of an inch above Poupart's ligament, and extending two inches downward. The skin and superficial fascia having been divided, the deep fascia is exposed and opened, when the sheath of the vessel is brought into view. The sheath being opened half an inch below Poupart's ligament, the femoral artery should be isolated from the femoral vein, which lies to the inner side. The anterior crural nerve lies to the outer side. The needle should be passed from within outward.

Ligation of the Femoral Artery at the Apex of Scarpa's Triangle.—This is considered the point of election for the ligation of the femoral artery from the fact that it is farthest removed from the main collateral branch, the profunda femoris artery.

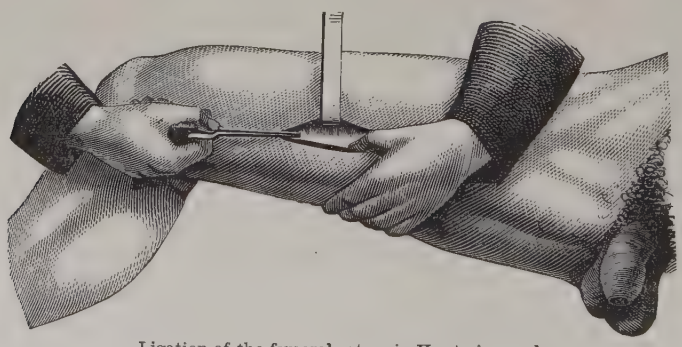
Fig. 297.

Ligation of the femoral artery in Scarpa's triangle. (Agnew.)

Operation.—An incision should be made three inches in length, the centre of which should be a little above the point where the sartorius muscle crosses a line drawn from the middle of Poupart's ligament to the inner condyle of the femur. The skin, superficial fascia, and deep fascia having been divided, the edge of the sartorius muscle will be exposed, which may be recognized by the direction of its fibres. The sartorius muscle is drawn outward and the sheath of the vessel is exposed and opened. The vein lies on the inner side of and somewhat behind the artery, and the long saphenous nerve is on the outer side. (Fig. 297.) The needle should be passed from within outward.

Ligation of the Femoral Artery in Hunter's Canal.—An incision three inches in length should be made along the tendon of the adductor magnus, the centre of which is at the junction of the lower and middle thirds of the thigh. (Fig. 298.) The skin, superficial fascia, and deep fascia having been divided, the sartorius muscle is exposed, and care should be taken not to injure the internal saphenous vein, which should be displaced.

Fig. 298.



Ligation of the femoral artery in Hunter's canal.

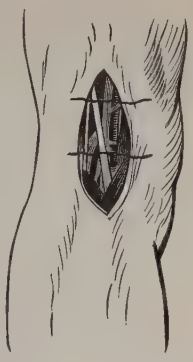
The sartorius muscle should be drawn downward, exposing the aponeurosis, which forms the anterior wall of the vascular canal; this should be opened upon a director, and the artery uncovered and separated from the vein, which lies upon the outer side. The needle should be passed from without inward.

Collateral Circulation.—When the femoral artery is tied below the origin of the profunda the blood finds its way to the limb below by anastomoses between the perforating branches of the profunda and the anastomotica

magna, with the articular arteries from the popliteal and the recurrent branch from the anterior tibial.

Ligation of the Popliteal Artery.—The popliteal artery extends from the opening in the adductor magnus muscle to the lower border of the popliteus muscle; it is accompanied by the popliteal vein and popliteal nerve, and gives off articular branches to the gastrocnemius muscle. An incision three or four inches in length should be made along the external border of the semi-membranous muscle. The skin and superficial fascia having been divided, the deep fascia is opened, care being taken not to injure the saphenous vein. The edges of the wound being held apart, the adipose tissue is broken up with a director, and the internal popliteal nerve will be first exposed, and next the vein; both of these structures are external to the artery. The artery is isolated and the needle is passed from without inward. (Fig. 299.)

Fig. 299.

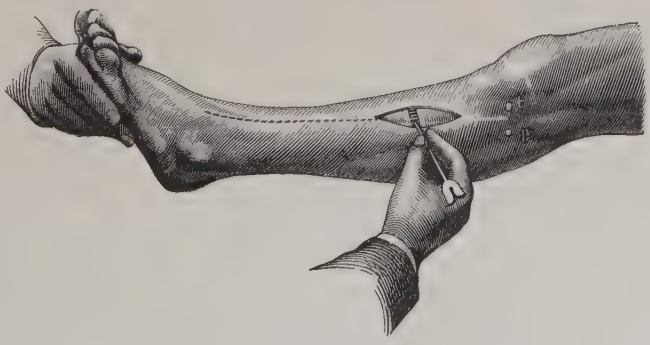


Ligation of the popliteal artery. (Agnew.)

Ligation of the Anterior Tibial Artery.—The anterior tibial artery begins at the lower border of the popliteus muscle, passes down the anterior portion of the leg, and, after passing in front of the ankle, reaches the dorsum of the foot and becomes the dorsalis pedis artery. The anterior tibial artery may be tied in the upper, middle, or lower third of the leg. The general direction of the artery corresponds to a line drawn from the middle of the space between the head of the fibula and the tubercle of the tibia and the middle of the anterior intermalleolar space.

Ligation of the Anterior Tibial Artery in the Upper Third of the Leg.—An incision from two and a half to three inches in length should be made one and a quarter inches external to the spine of the tibia. (Fig. 300.) The skin and superficial fascia having been divided, the deep

Fig. 300.



Ligation of the anterior tibial artery. (Agnew.)

fascia should be opened on a line corresponding with the intermuscular space between the tibialis anticus and extensor longus digitorum muscles, separating these muscles and working down in this interspace until the

artery is found, with a vein on either side of it, and the anterior tibial nerve externally. The needle should be passed from without inward after isolating the veins.

Ligation of the Anterior Tibial Artery at its Middle Third.—An incision three inches in length should be made in the same line as that for the upper portion of the vessel. The skin, superficial fascia, and deep fascia being divided, the interspace between the tibialis anticus and extensor longus digitorum muscles is opened, and a third muscle comes into view, the extensor proprius pollicis; the artery lies between the extensor proprius pollicis and the tibialis anticus, and the anterior tibial nerve is to the outer side. The veins should be isolated, and the needle passed from without inward.

Ligation of the Anterior Tibial Artery in its Lower Third.—The artery is exposed by an incision two inches in length on the line of the artery, beginning three inches above the ankle-joint. The skin, superficial fascia, and deep fascia having been divided, the tendon of the extensor proprius pollicis muscle, the second tendon from the tibia, should be sought for. The artery is found in the interspace between the extensor proprius pollicis tendon and the tendon of the extensor longus digitorum, the anterior tibial nerve being to the outer side. The veins being isolated from the artery, the needle should be passed from without inward.

Ligation of the Dorsalis Pedis Artery.—An incision one inch in length should be made on a line drawn from the middle of the anterior intermalleolar space to a point midway between the extremities of the first two metatarsal bones, or an incision may be made along the outer border of the extensor proprius pollicis. The skin and the superficial and deep fasciæ having been divided, the artery will be found lying inside of the inner tendon of the short extensor of the toes; the nerve is to the outer side. After separating the veins, the needle should be passed from without inward.

Ligation of the Posterior Tibial Artery.—The posterior tibial artery begins at the lower border of the popliteus muscle and runs down the back part of the leg, crossing as it descends to the tibial side. In its descent the artery rests upon the tibialis posticus and flexor longus digitorum muscles.

The course of the artery is indicated by a line drawn from the middle of the popliteal space to a point midway between the tendo Achillis and the internal malleolus of the tibia. The posterior tibial artery may be ligated in its upper, middle, or lower third.

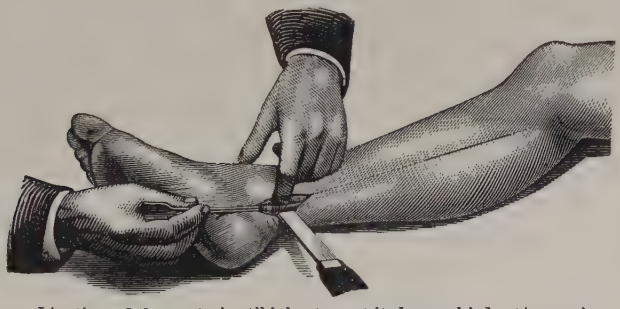
Ligation of the Posterior Tibial Artery at its Upper Third.—An incision three and a half inches in length should be made half an inch from the inner edge of the tibia, beginning two inches below the head of the bone. (Fig. 301.) The skin and superficial fascia being divided, care being taken to avoid large superficial veins, the deep fascia is opened, and the origin of the soleus muscle is detached from the tibia; upon raising it, its under surface will present a white, shining sheath of tendinous material, beneath which will be seen a layer of fascia covering the tibialis posticus muscle. If search be made towards the middle of the leg,

the artery will be found covered by the intermuscular fascia, the nerve being to the outer side. The needle should be passed from without inward after the veins have been separated from the artery.

Ligation of the Posterior Tibial Artery at its Middle Third.—An incision two and a half inches in length should be made parallel with the inner edge of the tibia and half an inch from its border. The skin and the superficial and deep fasciæ should be divided, and the inner edge of the soleus muscle will be exposed; displace this outward, and the artery with its veins will be exposed, also the posterior tibial nerve to the outer side. The needle should be passed from without inward after separating the veins.

Ligation of the Posterior Tibial Artery behind the Inner Malleolus.—A curved incision two inches in length should be made midway between the tendo Achillis and the internal malleolus. (Fig. 301.)

Fig. 301.



Ligation of the posterior tibial artery at its lower third. (Agnew.)

Having divided the skin and superficial fascia, the deep fascia should be lifted upon a director and freely opened, when the artery will be exposed, with the tendons of the tibialis posticus and flexor longus digitorum muscles on the inner side, and the posterior tibial nerve and tendon of the flexor longus pollicis muscle on the outer side. The veins should be separated from the artery, and the needle passed from without inward.

CHAPTER XVIII.

SURGERY OF THE NERVES.

NEURITIS.

Neuritis consists in an inflammation of the connective tissue of the peripheral nerves, and may occur from exposure to cold, or from wounds or other injuries of nerves, or arise from constitutional diseases, such as rheumatism, gout, syphilis, typhoid fever, or from the exanthemata, or from the toxic action of certain drugs, such as lead, mercury, arsenic, and alcohol. The affection may exist as an acute or as a chronic neuritis, and it may involve a single nerve, giving rise to a localized neuritis, or a number of nerves simultaneously, producing a multiple neuritis.

Acute Neuritis.—This affection is characterized by pain, extending downward in the course of the distribution of the nerve, which is remittent, is worse at night, and is aggravated by pressure or motion of the part; there are also a certain amount of febrile disturbance, numbness and tingling in the area supplied by sensory filaments, and marked hyperæsthesia, which, if the affection exists for any considerable time, may be followed by anæsthesia. Reflex phenomena in other parts may also be developed. Spasmodic muscular jerking in the early stages of the affection, if motor filaments are involved, may be followed by paralysis and muscular wasting. Acute neuritis often begins with inflammation of the sheath or perineurium, which is followed by œdema of the sheath, with marked increase in the connective-tissue elements of the nerve and softening of the nerve-tubules from granular and fatty changes, as well as from inflammatory exudates. Acute neuritis may result from exposure to cold, or from contusions or wounds of nerves; the affection is not infrequent after punctured wounds, and the contusion or laceration of nerves following fractures and dislocations, and strains or ruptures of fibrous tissue, fasciæ, and muscles. Acute neuritis is most likely to be confounded with neuralgia or rheumatism, but may be differentiated from the latter affection by the fact that the pain occurs in the track of a nerve, and that it is later followed by sensory, motor, or trophic changes.

Treatment.—In the treatment of this affection heat or cold may be applied, as is most comfortable to the patient; anodyne applications may also be employed. The part should be put at rest, a splint being applied to the part when it is possible. If the pain is intense, hypodermic injections of morphine and atropine should be used. In the subacute stage of the affection counter-irritation and the use of the galvanic current are often followed by satisfactory results.

Chronic Neuritis. — This condition may follow acute neuritis or may develop slowly from long-continued irritation of nerves from local or constitutional causes. In this affection there is marked sclerosis of the connective tissue of the endoneurium, with pressure on the nerve-tubules, which produces degeneration and atrophy of the same. Chronic neuritis may exist as an ascending or a descending neuritis; the former, however, is more common. This form of neuritis is also apt to be confounded with neuralgia or rheumatism, but the development of sensory, motor, and trophic disturbances will often show the true nature of the affection.

Treatment.—Pain, if prominent, should be relieved by the hypodermic use of morphine, atropine, or chloroform; counter-irritation by the use of blisters, or the actual cautery, may be employed with benefit. The faradic or constant galvanic current should be employed in cases in which there are paralysis and muscular wasting. The patient should be well fed, and care taken that he secures sleep. Strychnine can often be used with advantage, and in rheumatic or syphilitic cases, or gouty cases, treatment appropriate for these affections should be instituted; in some cases nerve-stretching may be resorted to with success. Recovery under any form of treatment is slow, and is often imperfect.

Neuralgia.—Neuralgia is an affection of the nerves, characterized by acute paroxysmal pain, which is referred to the areas of their distribution, and often without discoverable organic lesions. Neuralgia is apt to occur in debilitated, anæmic, and neurasthenic subjects, and in those who suffer from constitutional affections, such as rheumatism, gout, or syphilis. Malaria is frequently associated with the development of neuralgia. Irritation of peripheral nerves may be a cause of reflex neuralgia. It may be excited by some source of local irritation: a carious tooth will often give rise to severe neuralgia, which will manifest itself at a point distant from the source of irritation; stone in the kidney may give rise to neuralgia of the testicle. The pain in neuralgia may follow accurately the course of distribution of a nerve, or it may be experienced over a considerable amount of surface, and is almost always unilateral.

Pathology.—In many cases of neuralgia no nerve-lesion can be discovered, while in others an obliterating arteritis or senile sclerosis has been demonstrated as the pathological lesion. Lesions of the sensory cells of the posterior roots of the spinal cord or of the spinal ganglia have been suggested as causes of some of the obscure cases of neuralgia.

Diagnosis.—Neuralgic pain may be diagnosed from inflammatory pain by the absence of fever and by the fact that the former is relieved by pressure, while the latter is aggravated by it. Neuralgia of joints is followed by no structural changes in the parts, which always occur in inflammatory affections.

Epileptiform Neuralgia.—This variety of neuralgia usually attacks the face, and may occur in any of the branches of the fifth pair of nerves, is accompanied by intense pain, and in some cases by muscular spasm. The attacks are intermittent, and the paroxysms of pain may last from a few seconds to a minute. The mucous membrane of the lips, gums, and nostrils

may be the seat of pain as well as the skin. The paroxyms may be brought on by exposure to a draught of cold air or by movement of the facial muscles. The patient often exercises great caution in the movement of the jaws or lips in eating and talking, from the frequency with which these movements bring on a paroxysm of pain.

Treatment.—The treatment of neuralgia in the majority of cases belongs to the domain of medicine, and consists in the use of anodynes and counter-irritants, and the employment of massage and the galvanic current, together with the use of constitutional remedies, such as iron, arsenic, quinine, strychnine, phenacetine, and antipyrin. Where, however, medicinal treatment fails to give relief, various operative procedures may be practised upon the nerves, such as neurectasy, or nerve-stretching, neurotomy, neurectomy, acupuncture, or galvano-puncture. The description of these various operations will be given under Operations upon Nerves.

The treatment of neuralgia due to the inclusion of a nerve in a mass of callus or a cicatrix consists in freeing the nerve from the compressing tissue by dissecting out the cicatrix or chiselling away the callus, and such operations are often followed by relief. Neuralgia due to bulbous enlargement of nerves in stumps after amputation is treated by excision of the bulbous ends of the nerves. Operations for the relief of neuralgia when none of the previously mentioned conditions are present are seldom followed by permanent relief, but occasionally such a fortunate result follows; in the majority of cases, however, temporary relief is obtained. In epileptiform and intractable facial neuralgias operative treatment alone is capable of giving relief. Neurotomy, neurectomy, and nerve-stretching (neurectasy) act by interrupting the transmission of stimuli along the nerve-trunks or branches and putting at rest an over-stimulated nerve-centre.

INJURIES OF NERVES.

Injuries of nerves are more common in the upper extremity than in the lower, from the fact that they are anatomically more exposed. Nerves may be injured by contusion or compression, or may be incised or lacerated.

Contusion of Nerves.—Nerves in exposed positions may suffer from contusion, such as the musculo-spiral nerve in the arm, the ulnar at the elbow, and the brachial plexus in the neck. Slight contusions of nerves are usually followed to a greater degree by loss of motion than by loss of sensation. Severe contusion of a nerve may be followed by a loss of function as marked as that following complete section of the nerve. We have recently had under our care a case of contusion of the external popliteal nerve following an outward dislocation of the knee, in which the loss of power in the parts supplied by the nerve was complete. (Fig. 302.) In this case, upon exposure of the nerve at the seat of injury some months afterwards it was found that about an inch of the nerve was converted into a fibrous cord; resection and suture were practised, with a satisfactory result. If after contusion of a nerve there is loss of muscular power, but it is still capable of conveying sensory impulses, the prognosis is good; but if after a few months

there is loss of both motor and sensory power, the prognosis is bad. In severe contusions there may be complete destruction of the nerve-fibres at the point of injury.

Treatment.—In cases of slight contusion of nerves no special treatment is indicated: the part should be kept at rest, and anodyne lotions applied, and usually in a short time the motor and sensory functions will be restored. In cases where there is little disturbance of the sensory function, with marked impairment of the motor function, rest and the use of massage and galvanism will usually be followed by improvement in a few weeks. In cases where there is complete loss of power, both motor and sensory, following contusion of a nerve, and improvement does not occur after a month or two under the employment of massage and galvanism, it may be necessary to expose the nerve at the point of injury, excise the injured portion, and unite the ends of the nerve by sutures.

Fig. 302.

Paralysis following contusion of the external popliteal nerve.

Compression of Nerves.—Compression of nerves may occur in various ways, and may result from the pressure of external objects, from malignant tumors or aneurisms, from displaced bones in fractures or dislocations, from inflammatory exudates or pus, or from the implication of a nerve in scar-tissue. The paralysis of the arm from pressure on the brachial plexus following the use of crutches is not an uncommon occurrence, and may also result from pressure on the brachial plexus in the axilla by enlarged glands in carcinoma of the breast. Pressure on nerves from the displaced bones in fractures or dislocations may give rise to marked symptoms. The musculo-spiral nerve is not infrequently affected in fractures of the humerus. (Fig. 303.) Paralysis of the parts supplied by this nerve has occurred from the use of Esmarch's tube applied tightly to control hemorrhage. Pain and loss of motor function in the sciatic nerve are also occasionally observed in cases of growths or abscess in the pelvis. Paralysis of the nerves of the arm from pressure often occurs during heavy sleep, especially a drunkard's sleep. Pressure from involvement of a nerve in a scar or callus, if sensory fibres be involved, is manifested by pain, while the implication of motor fibres will be followed by muscular weakness or paralysis. In cases of paralysis from pressure upon nerves, the effects are generally slowly developed; sensory symptoms are first manifested by tingling, are usually earliest developed,

Fig. 303.

Wrist-drop following involvement of the musculo-spiral nerve in fracture of the humerus.

and are followed by more or less anæsthesia; motor symptoms are manifested by muscular feebleness or tremor, followed by paralysis.

Treatment.—The treatment of paralysis from pressure upon nerves consists in removing the cause; if the symptoms be due to a growth which can be removed, this should be accomplished; if due to a scar, this should be dissected out and the nerve found and thoroughly stretched. In cases of paralysis from the use of crutches, these should be abandoned for a time, and after the removal of the cause the loss of sensation resulting from the pressure should be treated by massage and galvanism.

Dislocation of Nerves.—Dislocation of a nerve, aside from its occurrence in connection with fractures or dislocations, is rarely seen. The ulnar nerve at the elbow, however, is occasionally dislocated by direct injury or forced extension of the forearm. A number of cases of dislocation of this nerve have been reported, and we have had recently under our care a case of dislocation of the ulnar nerve from direct violence. The symptoms of this injury are usually numbness and tingling in the parts supplied by the ulnar nerve, and the patient often feels something slip near the inner condyle of the humerus upon extension and flexion of the arm. Upon examination the surgeon can feel a cord in front of the inner condyle when the arm is flexed, which slips back into its groove when the arm is extended. In some cases the symptoms following this injury gradually disappear, the nerve accustoming itself to its changed position; in others, more or less pain, numbness, and disability persist.

Treatment.—This consists in replacing the nerve and holding it in place by a compress and bandage, at the same time fixing the motion of the elbow-joint by means of a splint. As this treatment usually fails to prevent recurrence of the dislocation, it is better to expose the nerve by an incision, and, after making a bed for it behind the inner condyle of the humerus, to fix it in its normal position by two or three chromicized catgut or kangaroo tendon sutures passed through the inner margin of the triceps tendon and somewhat loosely around the nerve; several sutures should also be applied to unite the divided margin of the fascial expansion of the triceps tendon superficial to the nerve.

Wounds of Nerves.—Wounds of nerves may be either incised, lacerated, or punctured.

Incised wounds of nerves are produced by sharp cutting instruments, such as knives, or by fragments of glass; accidental division of nerves is most frequent from glass wounds caused by thrusting the hand or foot through a pane of glass or from the breaking of glass vessels.

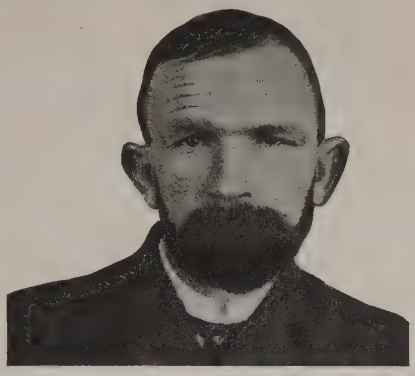
Lacerated wounds of nerves may occur in connection with extensive laceration of other parts, as is frequently seen in machinery and railroad accidents, in fractures or dislocations, or in gunshot wounds.

Punctured wounds of nerves generally result from needles, pins, or nails, and are not usually followed by complete loss of function, but may give rise to neuralgia or neuritis.

Symptoms.—The immediate symptoms following the division or extensive laceration of a mixed nerve are not always distinctive; the pain may be slight or may be severe. The muscles supplied by the divided nerve are

immediately paralyzed, and remain in this condition so long as the nerve remains ununited. (Fig. 304.) At the end of three or four days they refuse to respond to a strong faradic current. Later, the muscular tissue wastes and degenerates, so that at the end of two or three months very little remains. Reaction to the galvanic current disappears more slowly, and may not be entirely lost for several months. While galvanic irritability is present the *reactions of degeneration* may be obtained, which are as follows. In a healthy muscle the cathodal closure contraction is greater than the anodal closure contraction; but after division of a nerve, when the muscle is undergoing degeneration, there is rapid loss of irritability in the affected nerve to the galvanic or the faradic current, and the muscles supplied by the nerve rapidly lose their irritability when excited with the faradic current, but show for several days increased irritability to the galvanic current. Instead of the short, quick contraction of the normal muscle we obtain a slow, deliberate contraction in the diseased muscle, with gradual increase in the anodal closure contraction, so that in a short time it becomes equal to or greater than the cathodal.

FIG. 304.



Paralysis of the occipito-frontalis on the left side from wound of the anterior temporal branch of the facial nerve.

The changes following division of a nerve containing sensory fibres are as follows. The patient is usually at once conscious of a numbness in the parts supplied by the divided nerve, the anæsthesia of the skin being most marked. In severe injuries, involving other tissues as well as the nerves, sensory disturbances are often masked by the pain and shock of the injury. In other cases there is no marked loss of sensibility in the parts supplied by the divided nerve, which condition can be accounted for only by anastomosis with neighboring nerves. Sensation may be lost immediately after the injury, but may soon return, the return of sensation being always more prompt than that of motion. In examining for anæsthesia, the point of a pencil or the points of compasses may be employed, and the surgeon should satisfy himself that the patient can both feel and locate the points of contact.

In addition, certain trophic changes occur in the tissues from which the nerve-supply is cut off, which may be manifested in the skin by a glossy appearance and the development of herpes or ulcers or superficial gangrene in the anæsthetic area. The nails may become thickened and curved, and present ridges upon their surface. The hair is often shed from the anæsthetic area, or becomes brittle. The joints may also become inflamed and swollen, presenting much the appearance of rheumatic arthritis, and fibrous ankylosis may result, causing marked impairment of function.

Repair of injured nerves is considered under repair of tissues, page 74.

When no union of a divided nerve occurs, collateral innervation may take place, analogous somewhat to the collateral circulation which occurs

after division and occlusion of blood-vessels, which explains the cases of apparent immediate regeneration after suture of nerves.

Treatment of Divided Nerves.—Recently divided nerves should be approximated by sutures; great care should be exercised to render the wound aseptic, so that healing may be obtained without suppuration. If the ends of the divided nerve are much torn or lacerated, they should be trimmed off or freshened so as to obtain a good surface for approximation. If the amount of lacerated tissue which has to be removed is considerable, it may be necessary to stretch both ends of the nerve before they can be brought into apposition. There may also be a considerable amount of retraction of the ends of the nerve, so that it will often be necessary to enlarge the wound before they can be found. The material used for sutures should be one which will be absorbed, such as fine chromicized catgut or kangaroo tendon. The sutures should be passed through the nerve and its sheath about an eighth of an inch from its cut extremity. As few sutures as possible should be used, two usually being sufficient. The sheath may also be united with a few sutures, and the sutures should be tied just tight enough to bring the divided ends of the nerve together. An ordinary sewing-needle is better than the bayonet-pointed surgical needle, as it does not injure the fibres in its passage. After applying the sutures the wound should be closed and dressed, and the part fixed in the best position to secure relaxation of the nerve. Restoration of function is usually slow; even after immediate union of divided nerves a certain amount of impairment of motion or sensation may be permanent. After union has occurred, the restoration of function may be hastened by the use of galvanism and massage.

Secondary Suture of Nerves.—Many cases of divided nerves do not come under the observation of the surgeon for weeks or months after the injury, at which time degenerative changes have taken place in them, and the ends are usually included in a mass of cicatricial tissue. The results of secondary suture have been so satisfactory that it is always well to make an attempt to approximate the ends of the nerve. In performing secondary suturing a free incision should be made over the line of the nerve, and it should be exposed above and below the point of division. It should then be traced upward and downward into the cicatricial tissue; the latter should be freely removed, and a fresh section made of each end of the nerve. The bulbous enlargement upon the peripheral end should be removed, as it consists largely of fibrous tissue, or the upper portion of it only should be left. If there is much separation between the freshened ends it will be found necessary to stretch the nerve freely, and by so doing the ends can usually be brought into contact. Two or three sutures of fine chromicized catgut or kangaroo tendon should next be passed through the ends of the nerve and secured, and the wound then closed and dressed. Restoration of function after secondary suture is very slow; marked improvement may not be manifested for months, or even years.

Punctured Wounds of Nerves.—The *treatment* of punctured wounds of mixed nerves which are followed by severe pain, muscular spasm, or hyperæsthesia of the skin, probably due to a neuritis, consists in putting the part at complete rest by the use of splints, the local use of anodyne applica-

tions, and counter-irritation by means of blisters or the cautery. If after the use of these remedies for a reasonable time the symptoms persist, the nerve should be exposed at the seat of injury and nerve-stretching should be practised.

Partial Division of Nerves.—It is probable that partial division of nerves is much more common than is generally suspected in subcutaneous wounds, and that the slight disturbance that occurs in such cases is due to the fact that the uncut fibres prevent retraction of the severed portions of the nerve, and union of the divided portions takes place in a short time.

Treatment.—If a partially divided nerve is exposed in a wound, the severed portions should be approximated by sutures. Secondary suturing of partially divided nerves may be undertaken if the disturbances of sensation and motion following the injury are marked, and this procedure is accomplished by exposing the nerve at the seat of injury and removing the cicatricial tissue surrounding it, and if little nerve-tissue is found to be present the nerve should be resected and the ends united by sutures. If only a small portion of the nerve is involved in the cicatrix, this may be dissected out and a few sutures applied to the portion of the nerve which has been loosed from the cicatrix.

Neuromata.—Neuromata are tumors growing upon or between the fasciculi of a nerve ; they are usually fibrous or fibrocellular growths attached to the sheath of the nerve, and are known as false neuromata. (See pages 91, 100.)

The *painful subcutaneous tubercle*, which is a small fibroma developed upon a cutaneous branch of a sensory nerve, is considered by some writers as a form of neuroma. Sarcomata and cysts may also develop upon nerves.

Treatment.—The tumor should be dissected from the nerve, if possible, without injury to the nerve-fibres ; this can be done in many cases of false neuromata. If, however, the tumor cannot be removed without dividing or excising a portion of the nerve, this should be done, and the divided ends of the nerve should be united to bring about speedy restoration of function. If the amount of the nerve-trunk removed is so extensive that the ends cannot be united by sutures, even after stretching the ends of the nerve, attempts should be made to unite them by neuroplasty, or nerve-grafting, or threads of chromicized catgut should be passed through the ends of the nerve and tied,—*suture à distance*,—and upon this framework, even if the gap is extensive, the reparative material from the ends of the nerve may be deposited, and union of the divided ends ultimately effected.

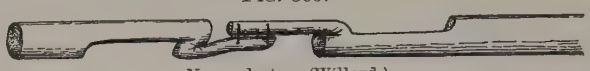
Plexiform neuromata, if not too extensive, or if upon parts where their presence causes great disfigurement, should be removed by dissection.

OPERATIONS UPON NERVES.

Nerve-Suture, or Neurorrhaphy.—The primary or secondary approximation of divided nerves by the application of sutures has been described under wounds of nerves. In exposing wounded nerves for suturing the use of Esmarch's bandage is most satisfactory, as its employment enables the operator to recognize the nerve and adjacent tissues. Nerve-sutures should be of some material which can be thoroughly sterilized and is capable of absorption in the tissues.

Nerve-Grafting.—Where it has been necessary to remove a considerable portion of a nerve, as, for instance, in the removal of a tumor or a neuroma, or where a portion of a nerve has been removed in an accidental injury, if it is found that the gap between the ends of the nerve is too great, even after stretching the ends, to permit of approximation with sutures, lengthening of the nerve may be done, as is practised in the case of tendons, a flap or flaps being turned from one or both ends of the divided nerve and united

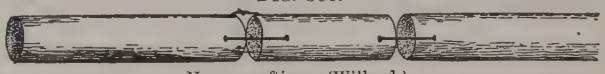
Fig. 305.



Neuroplasty. (Willard.)

by sutures. (Fig. 305.) The gap may also be filled by a graft of nerve-tissue: a section of nerve from a recently amputated limb, if it can be obtained, or, if not, a piece of nerve from a freshly killed animal, is cut of sufficient length to fill the gap, and is sutured to the nerve at each end by chromicized catgut

Fig. 306.



Nerve-grafting. (Willard.)

sutures. (Fig. 306.) It is probable that nerve-grafts simply act as a framework for the deposit of new tissue, but some experimenters assert that the grafts produce embryonic nerve-fibres capable of assisting in reunion.

Neurectasy, Neurotony, or Nerve-Stretching.—Nerve-stretching or elongation is a procedure in which the nerve is exposed and stretched in both directions. It has been shown by the experiments of Vogt that a nerve is capable of an elongation of one-twentieth of its length, the greatest elongation occurring at its spinal extremity. The amount of force that can be applied to an undivided nerve without producing rupture is a matter of importance in the operation of nerve-stretching. The force required to rupture the *sciatic* nerve is from one hundred to one hundred and sixty pounds; the *median*, *musculo-spiral*, and *ulnar* nerves will resist a strain of from fifty to eighty pounds; the *facial* nerve will stand a strain of from seven to twelve pounds. Traction upon the nerve from the spinal cord towards the periphery is said to have more effect upon the sensory fibres, while traction upon the nerve from the periphery towards the spine is said especially to affect the motor fibres. The changes produced in the nerve by stretching are detachment of the sheath from the nerve, rupture of the blood-vessels of the sheath, and dilatation of the vessels of the substance of the nerve; laceration of the nerve-tubules is in proportion to the violence employed. Degeneration of the nerve-fibres occurs, which in time is followed by the formation of new nerve-fibres and complete regeneration of the nerve. There is probably a distinct impression produced upon the spinal cord by nerve-stretching, as experiments upon animals show very decided lesions of the cord, such as hemorrhages and inflammatory exudations, as the result of this procedure.

The physiological effect of nerve-stretching is shown by decreased con-

ducting power, numbness or complete anæsthesia, diminution or loss of muscular power, and in some cases trophic changes.

Operation.—The nerve should be exposed by incision and isolated, and if it be a small one, as the facial, an aneurismal needle should be passed under it and it should be stretched in both directions; if a large nerve, such as the sciatic or median, or the brachial plexus, a finger or fingers should be placed under it, and it should be stretched in both directions, care being taken to keep the force applied well within the limit of the breaking strain. The *bloodless method* of nerve-stretching is applied only to the sciatic nerve, which may be stretched by placing the patient upon his back, with the leg extended at the knee, and flexing the thigh forcibly upon the pelvis, forced flexion being continued for ten or fifteen minutes. The patient should be anæsthetized before this manipulation is practised.

Application.—In nerve-stretching it is probable that the tearing or stretching of the tubules extends far beyond the immediate seat of operation, affecting even distant branches, and this is possibly the reason why this operation is more satisfactory in certain cases than neurotomy or neurectomy. Nerve-stretching may be employed with advantage in cases of neuralgia and chronic neuritis. In neuralgia following injuries of nerves, when the nerves are compressed by scar-tissue or present inflammatory thickening, the results following this procedure are often most satisfactory. In such cases the nerve should be separated from the scar-tissue and thoroughly stretched. Nerve-stretching has been employed in cases of paralysis, epilepsy, and tetanus, and for the relief of the lightning pains of tabes dorsalis, but apparently without permanent benefit. In dealing with mixed nerves, nerve-stretching should be preferred to neurotomy or neurectomy, as the former operation is followed by only temporary loss of motion and sensation, while the latter produces not only anæsthesia, but also permanent muscular paralysis.

Neurotomy.—Neurotomy, or nerve-section, is the intentional division of a nerve, and is a procedure which is practised for the relief of pain or spasm. In performing this operation the nerve is exposed at a convenient position and is divided with the knife or scissors. Owing to the fact that union of the divided nerve soon takes place, which is often followed by a return of the troublesome symptoms, this operation is not now much employed and has largely been superseded by the operation of neurectomy.

Neurectomy.—This operation consists in the exposure and resection of a considerable portion of a nerve, so that a wide gap exists between its ends. Neurectomy is frequently employed in cases of neuralgia and muscular spasm with satisfactory results. As union of the ends of the divided nerves sometimes takes place, even though a considerable portion has been removed, as is evidenced by the return of the symptoms, the ends are often turned back, or portions of muscle or fascia are interposed to prevent their reunion.

Nerve-Avulsion (Thiersch).—In this operation traction on the trunk of a peripheral nerve is employed to tear it at its central origin. The nerve being carefully separated from the surrounding connective tissue, the forceps, which resemble Lister's forceps, having one concave and one convex blade, are fastened at right angles to the nerve, and the nerve is twisted. The torsion must be done slowly, a half-turn every second. In this manner

not only the main peripheral trunk but all its branches are twisted into one common cord, until it becomes more or less fixed in some bony canal or at its ganglion; then, as the axis cylinder is broken by twisting, gentle traction is sufficient to sever the surrounding sheath.

Where it is impossible to reach the peripheral portion, the nerve may be divided in its middle, and the central end twisted; the peripheral end should then be pulled out of the wound as far as possible and cut off, in order to prevent any possible chance of reunion.

Fig. 307.

Exposure of the supra-orbital nerve. (Agnew.)

The operations of nerve-stretching, neurotomy, neurectomy, and nerve-avulsion are often practised upon the following nerves:

The Supra-orbital Nerve.—This nerve emerges from the supra-orbital foramen or notch at the junction of the middle and inner thirds of the eyebrow. It may be exposed by an incision about three-fourths of an inch in length, made parallel with the eyebrow and just beneath it (Fig. 307); the scar resulting will be hidden by the folds of the skin. The supratrochlear nerve lies half an inch to the inner side of the supra-orbital notch, and may be exposed by a like incision.

The Superior Maxillary Division of the Fifth Nerve.—This nerve may be exposed by a curved incision one and a half inches long, just below the lower border of the orbit. The position of the foramen of exit is one-fourth of an inch below the orbit, on a line drawn from the supra-orbital notch to the canine tooth of the same side. The nerve lies deeper than would be expected, by reason of the concavity of the surface of the superior maxillary bone and because it is covered by the elevator muscle of the upper lip. The nerve being exposed by the incision previously described, it is seized with hæmostatic forceps, or a ligature is tied around it to be used for the purpose of traction upon it. (Fig. 308.) A portion of the edge of the orbit just over the foramen is cut away with a chisel, the tissues of the orbit are pushed upward with a retractor, the thin bony wall between the orbital cavity and the nerve-canal is broken through with a director or elevator, and the nerve is exposed. It is then grasped with forceps and cut off with blunt scissors as far back as possible. The terminal filaments should next be torn loose from the skin and muscles by traction upon the distal end of the nerve with forceps. The infra-orbital artery, which accompanies the nerve, is sometimes injured, and gives rise to free hemorrhage, which can be controlled by packing the cavity with a strip of iodoform gauze.

Fig. 308.

Exposure of the infra-orbital nerve. (Agnew.)

Removal of Meckel's Ganglion.—The incision for the removal of this ganglion should be a curved one, extending from canthus to canthus, about a fourth of an inch below the orbit. If more room is required, this incision may be supplemented by a straight incision made at right angles to the first one. The infra-orbital nerve is found, and a ligature attached to it. The anterior wall of the antrum is next perforated with a three-quarter-inch trephine or a gouge, including the infra-orbital foramen. The posterior wall of the antrum is then perforated with a half-inch trephine or a gouge. In removing the section of bone from the posterior wall great care should be taken to avoid injury of the internal maxillary artery, which lies just behind the opening in the bone. The nerve is next divided in advance of the foramen, and after breaking down the wall of the bony canal it is traced back to the spheno-maxillary fossa and to the foramen rotundum, and the nerve and ganglion just below the foramen are cut away with blunt-pointed curved scissors. Hemorrhage is controlled by packing the wound with strips of iodoform gauze; after this has been controlled the wound is closed with sutures.

Inferior Dental Nerve.—This nerve is exposed by a horizontal incision two inches in length behind the angle and along the border of the lower jaw, which is less likely to divide branches of the seventh nerve than a vertical incision would be. The incision is carried down to the bone, the soft parts are pushed upward on the vertical ramus, the posterior portion of the masseter muscle is pushed forward, and when the angle of the jaw is fully exposed a half-inch trephine is applied an inch and a quarter above the angle. When the disk of bone has been removed the nerve is exposed in the canal, is lifted and stretched with an aneurismal needle, and as much as possible of it is resected. If the inferior dental artery is wounded, free bleeding occurs, which can be controlled by ligatures, or by plugging the canal with a piece of catgut, or by packing with iodoform gauze.

The inferior dental nerve may also be exposed through the mouth. The mouth being held open with a gag on the opposite side, an incision should be made along the anterior border of the lower jaw, extending from the last upper molar to the corresponding tooth in the lower jaw. After division of the mucous membrane the finger should be inserted between the internal pterygoid muscle and the ramus of the jaw, to separate the muscle and feel for the sharp projection of bone which marks the orifice of the inferior dental canal. An aneurismal needle should then be passed forward from the inner aspect of the jaw, and the nerve should be hooked upon this and drawn forward. In resecting the nerve care should be taken not to injure the inferior dental artery, which will give rise to troublesome hemorrhage.

For operations upon the Gasserian ganglion, see Surgery of the Head.

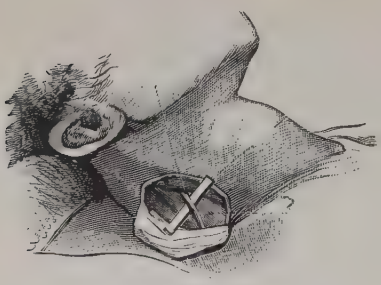
The Lingual Nerve.—This nerve may be exposed by passing a ligature through the tongue and pulling it forcibly towards the opposite side to make the nerve tense; the nerve can then be felt as a firm cord beneath the mucous membrane of the floor of the mouth between the jaw and the tongue. An incision is made through the mucous membrane at this point, and the nerve is raised upon an aneurismal needle and resected or stretched. It may also be found under the mucous membrane close to the lower jaw

under the last molar tooth. Resection of this nerve is sometimes resorted to in cases of neuralgia or malignant disease of the tongue for the relief of pain.

The Facial Nerve.—This nerve may be exposed at its point of exit from the stylo-mastoid foramen by an incision behind the ear carried from the level of the external auditory meatus downward and forward to the angle of the jaw. After dividing the skin and fascia the aponeurosis of the sterno-mastoid is exposed and retracted; the posterior border of the parotid gland is also exposed, and should be drawn forward. The prevertebral muscles and their fascia are next exposed, and the nerve lies in front of these. It should be lifted upon an aneurismal needle, cleared of surrounding tissues, and resected. To locate the nerve accurately it may sometimes be necessary to use a fine-pointed electrode, with a sponge electrode upon the cheek.

The Spinal Accessory Nerve.—This nerve is exposed by an incision the centre of which is opposite the hyoid bone, and which is made parallel to the anterior margin of the sterno-mastoid muscle. This muscle should be strongly retracted, when the nerve will be found crossing the carotid artery and internal jugular vein, penetrating the muscle from its under surface. (Fig. 309.) The nerve when exposed is lifted upon an aneurismal needle and resected. Resection of this nerve is frequently resorted to in cases of spasmodic wry-neck.

FIG. 309.



Exposure of spinal accessory nerve. (Agnew.)

The Cervical Plexus.—The nerves of the cervical plexus may be exposed by an incision parallel with the posterior border of the sterno-cleido-mastoid muscle near its middle.

The Brachial Plexus.—The nerves of this plexus may be exposed in the neck or in the axilla. The cords of the brachial plexus may be exposed in the neck by an incision parallel with and just above the clavicle, similar to that for ligation of the subclavian artery. To expose the cords of the plexus in the axilla an incision is made similar to that employed in ligation of the brachial artery in the axilla.

The Median Nerve.—This nerve is exposed in the upper arm by an incision two inches in length parallel to the inner border of the biceps muscle near its middle; the nerve crosses in front of the artery from without inward. The median nerve may also be exposed in the bend of the elbow, or by an incision two inches in length at the inner side of the palmaris longus tendon just above the wrist.

The Musculo-Spiral Nerve.—This nerve may be exposed at the middle or lower third of the arm. It is reached with the greatest ease in the latter situation by an incision two inches in length on a line drawn from the external condyle to the insertion of the deltoid muscle. After dividing the skin and fascia the nerve can be felt with the finger upon the humerus in the groove between the brachialis anticus and supinator longus muscles.

The Ulnar Nerve.—The ulnar nerve may be exposed in the middle of the arm, just above the elbow, or in the forearm. In the middle of the arm it may be exposed by an incision similar to that for exposure of the median nerve, and is to be sought for to the inner side of this nerve. It is exposed with the greatest ease behind the elbow, where it can be felt in a groove between the inner condyle and the olecranon process. In the lower part of the forearm it may be exposed by an incision along the radial border of the flexor carpi ulnaris muscle.

The Radial Nerve.—This nerve may be exposed by an incision similar to that employed in ligation of the radial artery in the forearm down to a point about three inches above the wrist, where it passes under the tendon of the supinator longus muscle to the back of the hand.

The Great Sciatic Nerve.—This nerve is exposed by an incision three or four inches in length, beginning just below the gluteo-femoral crease on a line from the middle of the popliteal space to a point a little to the inner side of the middle of a line drawn from the great trochanter to the tuber ischii. After dividing the skin and fascia the gluteus maximus muscle should be drawn outward and upward, and the biceps muscle drawn inward, when the nerve will be brought into view.

The Internal Popliteal Nerve.—This nerve lies under the deep fascia in the middle of the popliteal space, and may be exposed by a longitudinal incision in this position.

The External Popliteal Nerve.—This nerve is exposed by an incision two inches in length on the inner side of the tendon of the biceps, a short distance above its insertion into the head of the fibula.

The Anterior and Posterior Tibial Nerves.—These nerves may be exposed at any point in the leg by incisions similar to those employed in ligation of the anterior and posterior tibial arteries.

CHAPTER XIX.

SURGERY OF MUSCLES, TENDONS, FASCIÆ, AND BURSÆ.

INJURIES OF MUSCLES.

Muscles.—Muscles may present incised, lacerated, and contused wounds; the latter varieties are often subcutaneous. Laceration of muscular tissue may result from the application of external force, or from the sudden, forcible, and unopposed contraction of a muscle. When the latter accident occurs, the patient usually experiences a sudden sharp pain, with a sense of giving way in the region of injury, and in attempting to move the part finds that there is disability to a greater or lesser extent. Extensive gaping may result from incised and lacerated wounds of the muscles, the amount of separation depending upon the direction and completeness of the division of the muscular fibres; transverse wounds present these symptoms in a more marked degree than longitudinal wounds. Subcutaneous rupture of the sterno-cleido-mastoid muscle during birth is probably only a partial rupture, giving rise to the condition known as *congenital tumor of the sterno-mastoid*, and may cause a form of wry-neck.

Strains and sprains of muscles are frequent injuries, and may consist in simple stretching of the fibres of the muscle, or in laceration of some of the muscular fibres; both of these injuries are capable of producing more or less loss of function in the injured muscle. Repair of muscular tissue takes place largely by the formation of fibrous tissue at the seat of injury.

Treatment.—Incised and lacerated wounds of muscles should be treated by the introduction of buried sutures, catgut or silk, between the ends of the divided muscle, to bring them in apposition. When a considerable portion of the muscle has been lost and it is impossible to approximate the ends, a number of strong chromicized catgut or kangaroo tendon sutures may be introduced to act as a framework for the deposit of reparative material,—*suture à distance;* or the gap may be filled by muscle-grafting, a graft of muscle being taken from a freshly killed animal and sutured to the ends of the muscle; the graft should be large enough to fill the gap without producing tension upon the ends of the muscle when sutured in position; even if the graft retains its vitality it is eventually converted into fibrous tissue.

Subcutaneous wounds of muscles, if not involving the whole thickness of the muscles, do not require the application of sutures, but if the muscles are completely torn across, the ends should be exposed by incision and buried sutures applied.

Strains and sprains of muscles are best treated by strapping, the straps of adhesive plaster being firmly applied, and additional support and fixation being given by the application of splints and bandages.

In all wounds of muscles the parts should be put completely at rest by the application of suitable splints, straps, and bandages.

Hernia of Muscles.—This condition consists in a protrusion of a portion of a muscle through a gap in the deep fascia overlying it, and generally results from wounds in which healing of the wound in this fascia has not taken place. The protrusion of the muscular tissue is usually marked upon contraction of the muscle, and is often accompanied by some impairment of muscular power.

Treatment.—In many cases, if the muscular protrusion is of small extent, no disability results and no treatment is required. In recent cases, however, when there exists a certain amount of disability, the application of a compress and bandage or of an elastic bandage for a time will often effect a cure. In severe cases, where the latter methods fail to give relief, it is better to cut down upon the hernia and expose the gap in the deep fascia; the edges of the fascia should be freshened, and brought into apposition by sutures of silk, chromicized catgut, or kangaroo tendon.

DISEASES OF MUSCLES.

Myalgia.—This disease, which is characterized by a painful condition of a voluntary muscle, may result from traumatic causes, such as strains or twists or slight lacerations, giving rise to inflammation of the muscular tissue, or may arise from acute infectious diseases, from syphilis, or from the toxic action of certain drugs, such as lead, mercury, or alcohol, and may be neuralgic in character. The *treatment* consists in putting the affected muscle at rest by the use of strapping or the application of splints, and the application of heat and anodyne lotions, or the hypodermic use of morphine and atropine.

Myositis.—This affection consists in an inflammation of the voluntary muscles, and may arise from traumatism or overuse of a muscle, from diathetic conditions, such as gout and rheumatism, from secondary syphilis, or gummatous infiltration, from infection followed by diffused suppuration, or from the presence of the embryos of the *trichina spiralis* in the muscular fibres. We had under our observation recently a lad who presented a marked inflammation of the biceps muscle, the muscle being tender and swollen, with loss of function; the condition had developed after a day's work in a blacksmith-shop, when he had constantly used a heavy sledge-hammer.

Treatment.—The treatment of myositis due to traumatism and overuse of the muscle consists in putting the muscle at rest and in the application of anodyne lotions. Myositis arising from rheumatism and syphilis will be relieved by treatment appropriate to those affections. Infective myositis and suppuration should be treated by incisions into the inflamed muscle, to secure free drainage. The muscular invasion of trichiniasis requires both constitutional and local treatment.

Degeneration of Muscles.—Muscular tissue as the result of inflammation or from long disuse may undergo fatty degeneration. In such cases the striated muscular fibre is preserved and the fatty degeneration is largely confined to the connective tissue. A more complete form of fatty degeneration, known as *intrinsic fatty degeneration*, is occasionally observed in muscular

tissue; in this form of degeneration the muscular tissue is converted into a fatty granular mass; *granular*, *waxy*, and *calcareous* degenerations of muscles are also occasionally observed. The *treatment* of fatty degeneration of muscles consists in the use of passive motion, massage, and the faradic current to improve their nutrition.

Ossification of Muscles.—Ossification of a portion of the belly of a muscle, or more frequently of its point of insertion into a bone, is occasionally observed as the result of long-continued irritation. The development of bone plates in the adductor muscle of the thigh, known as *rider's bone*, is not infrequent in those who ride on horseback constantly. We have observed a case in the brachialis anticus of a young man consequent upon repeated blows of the fist.

Myositis ossificans is a rare affection, in which there is a wide-spread ossification of the muscles following a general muscular inflammation. The cause of this affection is unknown. Its course is slow, and is unaffected by treatment; death usually results from exhaustion or involvement of the respiratory muscles.

Atrophy of Muscles.—Atrophy of muscular tissue may arise from disuse, from nerve injury, from disease of the joints or of the spine, or from contusion, as is often seen after contusions of the shoulder. (Fig. 310.) Muscular atrophy is a prominent symptom in progressive muscular atrophy and infantile paralysis. Muscular atrophy may also be associated with fatty degeneration of the muscles.

Fig. 310.

Atrophy of the muscles of the left shoulder following contusion.

Hypertrophy of Muscles.—A muscle may increase in size from actual increase in the number and size of the muscular fibres through unusual action of the muscle, or from increase in the connective tissue, lymphatics, or blood-vessels of the muscle.

Contracture of Muscles.—This affection, which consists in a permanent shortening of a muscle—that is, the approximation of its point of origin and its point of insertion—may result from many causes, such as inflammation, loss of substance, diseases of contiguous joints, paralysis of opposing muscles, cicatricial contraction, diseases of the central nervous system, hysteria, and chorea. Ricord has described a form of contracture in muscles, particularly in the biceps, which results from syphilis.

The treatment of contracture of muscles is considered in the article upon Orthopædic Surgery.

Tumors of Muscle.—Muscular tissue may be the seat of carcinomatous, sarcomatous, syphilitic, fibrous, cystic, vascular, cartilaginous, or osseous growths. The treatment of these affections depends largely upon their nature; non-malignant growths can often be removed by dissection; malignant growths involving muscles of the extremities call for excision of the growth, or in many cases for amputation of the limb.

INJURIES AND DISEASES OF FASCIÆ.

Wounds of Fasciæ.—The various fasciæ of the body which invest and compress the muscles and separate them from one another are often exposed to injury. Owing to the fact that the fascia is poorly supplied with blood-vessels, it is apt to become gangrenous from inflammation of surrounding tissues interfering with its nutrition. Wounds of the deep fascia are apt to be followed by hernia of the subjacent muscles. We have seen rupture of the deep fascia over the soleus muscle occur in gouty subjects from forcible flexion of the foot. Wounds of fasciæ are of especial interest to the surgeon, from the fact that they open up certain planes of tissue in which suppuration may occur and cause wide-spread destruction of the tissues.

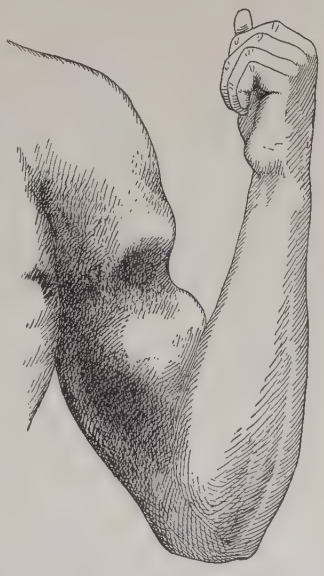
Treatment.—The treatment of an open wound of the deep fascia consists in approximating the edges of the fascia with sutures; if destruction of a portion of the fascia has occurred, from its inelastic character it is not possible to bring the edges into contact. Subcutaneous wounds of the deep fascia unaccompanied by hernia of the muscles should be treated by rest, position, and fixation of the parts by strapping and splints.

Contraction of Fasciæ.—As the result of inflammation following traumatism, or of certain diathetic conditions, such as gout or rheumatism, shortening of fasciæ may occur, giving rise to marked deformities; the deformities arising from contraction of the fascia lata, the popliteal fascia, and the palmar fascia are familiar to every surgeon. The treatment of these conditions will be considered under Orthopædic Surgery.

INJURIES AND DISEASES OF TENDONS.

Rupture of Tendons.—Complete or partial rupture of a tendon may occur from sudden violent effort, producing unusual muscular contraction. When such an accident occurs, the patient experiences a sense of something giving way and sharp pain at the seat of injury, which is followed by loss of muscular power. The tendons in which this accident is most likely to occur are those of the quadriceps extensor femoris, the long head of the biceps (Fig. 311), the ligamentum patellæ, the triceps, and the tendo Achillis. Loss of function following this injury is usually very marked, and examination will often reveal a decided gap between the torn ends of the tendon. Avulsion of tendons may result from machinery accidents: the fingers or toes being caught in machinery, the tendons are torn out, often with a portion of the attached muscles. The injury described as rupture of the ligamentum patellæ or of the tendon of the quadriceps extensor femoris often consists not in a rupture of the tendon, but in a tearing away of the insertion of the tendon from the patella, stripping off a portion of the periosteum and fibrous capsule with

Fig. 311.



Rupture of long head of biceps muscle. (After Treves.)

occasionally some particles of the bone: the symptoms of this injury are similar to those of rupture of the tendon.

Treatment.—In case of a ruptured tendon it is possible to have repair take place, if the gap between the ends is not too extensive, by putting the parts at rest and in such a position as to favor the apposition of the ends of the tendon. The time required, however, is considerable, and the functional result may be imperfect. In view of these facts, it is wiser to treat cases of ruptured tendon by exposing the ends by incision and suturing them together with silk, chromicized catgut, or kangaroo tendon sutures, and after dressing the wound applying a plaster of Paris bandage to fix the part and hold it in such a position as will secure the greatest relaxation of the injured tendon. In cases of tearing away of the insertion of the tendon of the quadriceps extensor femoris or ligamentum patellæ from the patella, to secure a satisfactory result it is often necessary to expose the separated tendon, and after drilling the patella at a number of points to pass kangaroo tendon or silk sutures through the perforations in the bone and through the ends of the tendon to fix its insertion in the normal position.

Wounds of Tendons.—Wounds of tendons may be punctured, incised, or lacerated, and may be subcutaneous or open. The subcutaneous variety of incised wounds is frequently produced in the ordinary operation of tenotomy, and the favorable course which these wounds run is known to every surgeon. Punctured wounds of tendons, unless septic matter is introduced by means of the puncturing instrument, are usually followed by little trouble. Open incised wounds of tendons are serious injuries, both as regards inflammatory complications which may arise if the wound becomes septic, and the loss of function which results if union of the divided ends of the tendon is not secured. These wounds are often seen in connection with incised wounds of the skin, fascia, and muscles, and result from injury by sharp-edged instruments, such as knives or scythes, or from broken glass. These wounds of tendons are usually seen about the hands and feet.

Treatment.—The divided ends of the tendon should be found, and fastened together by the introduction of one or two sutures of silk, catgut, or kangaroo tendon. Difficulty is sometimes experienced in locating the proximal end of the tendon, it often being so much retracted that it becomes necessary to enlarge the wound to find it. It is well also to suture the divided sheath of the tendon with a few sutures of fine silk or catgut. The wound should be carefully dressed, and the part placed in the position of relaxation and put at rest by the application of a splint or plaster of Paris bandage.

Lacerated wounds of tendons should be treated in the same manner. Here it may be necessary to trim away some of the lacerated tissue to obtain a good surface for apposition.

Secondary Suture of Tendons.—It sometimes happens that the division of a tendon escapes notice at the primary dressing of a wound, and after healing has occurred it is found that there is a certain amount of loss of function, which points to the division and non-union of the tendon. In such a case the ends of the divided tendon should be exposed by an incision; and there is here often considerable difficulty in finding the proximal end, which is generally greatly retracted. When exposed, the ends of the tendon

should be freshened and brought into apposition by two or three sutures of catgut or silk passed through them some distance from their edges, so that they will not be likely to cut out before union occurs. If it is found impossible after stretching the proximal end of the tendon and its attached muscle to bring it into contact with the distal end, sutures may be introduced between the ends, even if a gap of some size exists, these sutures serving as a framework for the deposit of reparative material; or some operation for lengthening the tendon may be undertaken. Secondary suturing of tendons is often followed by the most satisfactory results.

Lengthening of Tendons.—This operation may be found necessary to increase the length of contracted tendons and muscles, or to lengthen a tendon so as to bring the divided ends together in the secondary suturing of tendons. It is best accomplished by introducing a knife and making an incision partly through the tendon, then splitting the tendon for a short distance and cutting through it, and suturing the ends as shown in Fig. 312. In case of marked retraction of the proximal end of a tendon, a flap may be turned down from the proximal end and sutured to the distal end, after the method of Czerny. (Fig. 313.)

FIG. 312.

Lengthening of a tendon.

FIG. 313.

Czerny's method of lengthening a tendon.

Dislocation of Tendons.—Tendons are occasionally, as the result of extreme violence, thrown out of their normal positions. This condition is sometimes observed in the tendon of the long head of the biceps, which may be thrown out of the bicipital groove, or the tendon of the peroneus brevis may be displaced forward, or the tendon of the tibialis posticus may be displaced from behind the internal malleolus. In the treatment of a displaced tendon, the use of a compress and bandage applied after the tendon has been replaced, and fixation of the part for a time, will often secure it in its normal position. If, however, this fails to control the tendency to displacement, the tendon should be exposed by an incision and sutured in its normal position, being held by a flap of periosteum or fibrous tissue sutured across it.

Teno-Synovitis or Thecitis.—Inflammation of the synovial sheaths of tendons may occur as an acute or a chronic affection. Acute teno-synovitis usually results from traumatism, and may present the symptoms of inflammation without suppuration, or may be accompanied by profuse suppuration if pyogenic organisms have gained access to the synovial sheaths.

Acute Non-Suppurative Teno-Synovitis.—This affection usually results from strains or sprains of the tendons and sheaths, or from unaccustomed excessive use of the parts, especially if accompanied by exposure to cold. This form of teno-synovitis is most frequently observed in the tendons about the wrist and those just above the ankle. The symptoms are pain,

loss of power in the affected muscles, and a peculiar dry crepitus when the tendon is moved in its sheath, which is sometimes mistaken for the crepitus of fracture.

Treatment.—The treatment of non-suppurative teno-synovitis consists in the application of tincture of iodine over the course of the inflamed tendon, or light stroking of the surface of the skin over the tendon with Paquelin's cautery, and the use of a splint to limit the motion of the affected part. In the later stages of the affection the local use of an ointment of equal parts of unguentum belladonnæ and unguentum hydrargyri, or strapping, will often be followed by good results. The affection usually subsides under this treatment in a few days, or at most in two or three weeks. Some crepitation may remain upon motion of the tendon long after all inflammatory symptoms have subsided.

Suppurative Thecitis.—This affection results from infection of the sheath of a tendon by pyogenic organisms which have gained access to it through an open or a punctured wound. In many cases the wound may be so insignificant as almost to escape notice. This disease often affects the flexor tendons of the hands and feet, and is accompanied by redness and swelling of the part, throbbing pain, and marked constitutional disturbance. Owing to the anatomical structure of the parts, the inflammation travels readily along the sheath of the tendons and the surrounding connective tissue, and unless the progress of the disease is arrested by free incisions sloughing of the tendons and sheaths as well as of the connective tissue is apt to occur, and in some cases necrosis of the adjacent bones results.

Treatment.—The treatment of suppurative thecitis consists in early and free incision and the subsequent application of warm, moist antiseptic dressings. If in spite of early incision the disease continues to spread and involves other tendons, the incision should be repeated at the new positions of inflammation. It is only by the employment of early and free incisions that sloughing of the tendons and of the connective tissue can be avoided. Fixation of the inflamed parts by a splint is an important detail in the treatment.

Fig. 314.

Synovial sheaths of fingers and common sheath for tendons of the palm, little finger, and thumb. (Keen.)

Palmar Abscess.—Palmar abscess may result from infection of the connective tissue or synovial sheaths of the flexor tendons in the palm of the hand, through a punctured wound, or from suppurative thecitis of the sheath of the flexor tendons of the fingers Because of the anatomical arrangement of the sheaths of the flexor tendons, the palm, thumb, and little finger having a general sheath, and those of the fore, ring, and middle fingers having separate sheaths (Fig. 314), the infective process is more likely to

terminate in palmar abscess if it originates in the sheath of the little finger or the thumb. The symptoms of palmar abscess are pain, swelling, œdema of the dorsal surface of the hand, and marked constitutional disturbance. If not subjected to prompt treatment, the pus may burrow along the tendons and enter the forearm, involving the connective-tissue planes or the articulations of the carpus. If the pus does not extend in this direction, it is apt to burrow backward and point on the dorsum of the hand between the metacarpal bones.

Treatment.—This consists in early and free incision of the palm; the incision or incisions should be made over the metacarpal bones, and, to avoid injury of the superficial palmar arch, they should be made in advance of the first transverse line running across the palm of the hand. After the abscess has been freely opened, moist antiseptic dressings should be applied, and the hand and forearm should be fixed upon a splint. Early incision usually arrests the progress of the trouble, but occasionally in spite of this treatment the infection spreads to the dorsum of the hand and the forearm, in which case incisions should be made at a number of points to secure free drainage.

Chronic or Tubercular Teno-Synovitis.—This affection is manifested by swelling and induration in and around the sheath of a tendon, due to the presence of granulation-tissue, or there may be irregular swellings, which present fluctuation, and which upon being opened are found to contain fluid and numerous whitish bodies resembling grains of rice or melon-seeds. Microscopic examination in these cases usually reveals the presence of tubercle bacilli. This disease is most frequently seen in connection with tendons at the wrist, ankle, and knee, and may develop after a slight injury of the tendons over these joints, such as a sprain or wrench, or may follow a tubercular affection of the joints. (Fig. 315.) The disease

Fig. 315.

Tubercular teno-synovitis of the tendons of the thumb. (Agnew.)

runs a slow course, and even when the swelling is marked there may be little pain and very slight impairment of function. It rarely undergoes spontaneous cure, but is more apt to become infected and suppurate, or to break down, forming a tubercular abscess.

Treatment.—In cases of tubercular teno-synovitis in which there is little thickening of the sheaths of the tendons and fluid is present in considerable quantity, the fluid should be removed by aspiration and the sac injected with iodoform emulsion, half a drachm being employed at one time, and the injections being repeated at intervals of a week. Under this method of treatment a cure may result in certain cases. Where, however,

there is a large deposit of gelatinous or tuberculous material, or where there are rice or melon-seed bodies, a more radical operation is required.

The part should be rendered bloodless by the application of Esmarch's bandage, and the swollen tissues freely exposed by incision; the thickened lining of the sheath should then be dissected out, or, if this is impossible, removed by curetting; the tendons themselves can generally be saved, even though the sheaths are freely excised. After removing the diseased structures thoroughly, the wound should be closed by sutures or packed with iodoform gauze, and if the infected tissue has been completely removed a cure may result. It is not uncommon for the disease to recur even after a very thorough removal of the diseased tissue, in which event the operation should be repeated. In relapsing cases the prognosis is not good, the patient often developing tuberculosis of the viscera, which causes a fatal termination.

Ganglion.—The generally accepted theory that ganglia were hernial protrusions of the sheaths of tendons has been controverted by the recent researches of Ledderhose and Thorn, who have proved that they are cystomata arising from gelatinoid degeneration of the tendon itself and of the para-articular tissues. They are most commonly seen in connection with the extensor tendons of the wrist and hands or upon the dorsum of the foot. They usually exist as small, oval, tense tumors, which contain a clear syrup-like fluid, and may develop slowly or rapidly upon a tendon which has been subjected to unusual strain or to more than ordinary exercise. These cysts may also develop in the capsular ligaments of joints.

Fig. 316.

Compound ganglion of thumb and wrist. (Agnew.)

A **compound ganglion** consists of a dilatation of the sheath of a tendon or of a number of tendons, and is really a form of tubercular teno-synovitis. (Fig. 316.)

Treatment.—The treatment of simple ganglion consists in a subcutaneous rupture of the sac by pressure with the thumb and finger or a blow with a book, or by a subcutaneous puncture with a tenotome followed by pressure, the contents escaping into the cellular tissue and being absorbed; a compress and bandage are then applied for a few days. Refilling of the sac, however, is apt to occur in a short time. A more radical method of treatment consists in exposing the tumor by incision and carefully dissecting it out; the connection with the joint must be carefully sought for, and, if present, the opening in the sac should be ligatured or sutured. In this operation the greatest care should be observed to keep the wound aseptic.

The treatment of compound ganglion has been described under the treatment of tubercular teno-synovitis.

Tumors of Tendons.—Growths involving the tendons or their sheaths may originate in the tendons primarily or may involve the tendons

by extension from without; they may be benign, malignant, or syphilitic. Occasionally a small fibroma is developed in a tendon, which will produce a very marked amount of disability.

Treatment.—The treatment of tumors of tendons consists in their removal by a careful dissection.

Ossification of Tendons.—Bone deposits are occasionally found in tendons, being most apt to occur at their points of insertion. This affection may result from rheumatoid arthritis, or from constant and prolonged irritation, or from the deposit of callus following injury of contiguous bones. Unless marked disability results from this affection, no operative treatment should be undertaken.

Felon, or Paronychia.—This is an infective cellulitis involving the soft parts of the fingers, usually the pulp over the distal phalanx, which often follows slight traumatisms, such as punctures, bruises, or scratches, and may ultimately involve the sheath of the tendons and the periosteum, causing necrosis of the distal phalanx. This accident is more apt to occur in case of the distal phalanx from the fact that it has no distinct periosteum, the vessels supplying the bone ramifying in the dense fibro-adipose tissue of the pulp of the finger. When the tendon and its sheath are involved, a suppurative teno-synovitis is set up, which may terminate in sloughing of the tendon or in palmar abscess. There are two varieties of this affection, the superficial and the deep. A **superficial felon** usually involves the tissue around and under the nail, may affect several fingers in turn, and is seen in debilitated subjects, and often in children. It is accompanied by pain, swelling, and redness of the tissues around the nail; suppuration occurs, and granulations protrude around the nail, whose vitality is so much impaired that it is apt to exfoliate.

Treatment.—The treatment of superficial felon consists in the application of a warm antiseptic gauze dressing and incision as soon as the presence of pus is indicated. If the vitality of the nail is destroyed, and it is surrounded by granulations and is keeping up irritation, it should be removed, and the granulations dusted with powdered nitrate of lead and covered with a dry antiseptic gauze dressing.

Fig. 317.

Felon. (Liston.)

Deep Felon.—The symptoms of deep felon are swelling, tension, fever, and throbbing pain of a very severe character, which is increased by the dependent position of the hand. (Fig. 317.)

Treatment.—The abortive treatment by the use of tincture of iodine or nitrate of silver is usually unsuccessful. Hot fomentations or antiseptic poultices often relieve pain, and may be employed for twenty-four hours; but the most satisfactory treatment consists in free incision, which is especially important if the distal phalanx be involved, to prevent necrosis of the bone. The incision should be made with aseptic precautions, and carried down to the bone. If the disease involves higher parts of the finger, the sheath of the tendon should be opened in the in-

cision. After making the incision, the part should be dressed with a warm, moist antiseptic gauze dressing, and the hand placed upon a splint. A free incision usually arrests the progress of the disease, but if so favorable a result does not follow, and the inflammation spreads up the finger and involves the palm of the hand, the same procedure may be required at higher points.

INJURIES AND DISEASES OF BURSÆ.

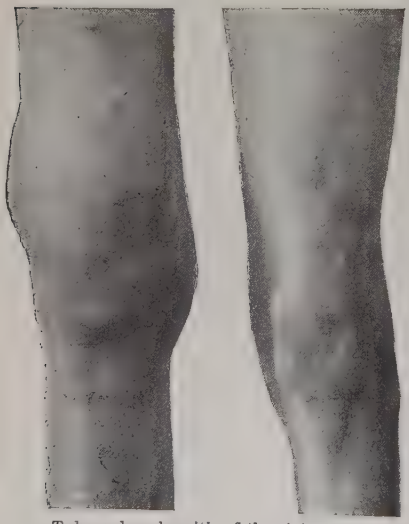
Synovial bursæ exist normally in connection with tendons or with certain joints, and may be developed by continued friction or pressure at certain parts of the body. Deep bursæ are sometimes connected with the joints, or are in very close relation with them.

Injuries of Bursæ.—Wounds of bursæ may be either contused, incised, lacerated, or punctured, and, if they become infected, may prove most serious injuries. Wounds of bursæ should be thoroughly disinfected and drained, and usually heal with obliteration of the sac.

Acute Bursitis.—This affection usually results from an injury or continuous irritation of a bursa, and is characterized by tenderness, pain, redness of the skin, and swelling or distention of the bursa. If suppuration occurs, the inflammation is apt to extend to the surrounding cellular tissue, or, if in close proximity to a joint, may involve this. Bursitis can usually be diagnosed from other affections by the rapidity of development of the inflammatory symptoms, the location of the swelling in relation to certain tendons or joints, and its globular shape.

Treatment.—This consists in elevating the part and putting it at rest on a splint, and in the application of cold or pressure. If, however, the pain and swelling due to effusion continue, and there is evidence of suppuration, the bursa should be freely opened and irrigated with a solution of carbolic acid or bichloride, and subsequently packed with sterilized or iodoform gauze. Under this treatment the cavity soon becomes obliterated as healing occurs. The bursæ most commonly involved are the prepatellar and the olecranon bursa, and that over the metatarsal joint of the great toe.

FIG. 318.



Tuberculous bursitis of the right knee.

Chronic Bursitis.—This affection may result from acute bursitis which does not terminate in suppuration, or may develop slowly from long-continued irritation or pressure, or from tubercular infection of the bursa (Fig. 318), and is accompanied by little pain. The most marked feature in chronic bursitis is the distention of the sac with fluid, and in some cases the walls of the sac become so much thickened that the bursa is converted into a solid tumor. Chronic bursitis of the prepatellar bursa is not infrequently met

with, and is commonly known as *housemaid's knee* (Fig. 319), resulting from long-continued pressure upon the knee, occurring in those whose occupation causes them constantly to bear pressure upon this part. Chronic bursitis with enlargement of the bursa over the olecranon is also occasionally seen, and is known as *miner's elbow*. Subdeltoid bursitis is sometimes observed.

Fig. 319.

Chronic bursitis of prepatellar bursa, or housemaid's knee.

Fig. 320.

Hernial protrusion of bursa following an injury.

Gumma of the prepatellar bursa is very common, and should be suspected in every case of suppuration of this bursa without assignable cause. It often results in extensive sloughing.

Hernial protrusion of a portion of a bursa is sometimes seen after injuries of bursæ. (Fig. 320.)

Disease of the subligamentous bursa is indicated by swelling upon the side of the ligament, which becomes most prominent when tension is made upon the ligamentum patellæ.

Treatment.—The treatment of chronic bursitis, if the sac is distended with fluid, consists in removal of the fluid by aspiration, or by making an incision and introducing a drainage-tube. The greatest care should be observed to keep the wound aseptic. The bursa may be removed by dissection. This is the only treatment which is likely to be of use in cases where the bursa is very thick or is converted into a solid tumor. In removing these growths by dissection great care should be exercised to avoid opening neighboring joints. Subligamentous bursæ are often treated by aspiration, as the risk of opening the joint is very great if attempts are made to dissect them out.

Bunion.—This is a bursal enlargement over the metatarso-phalangeal articulation of the great toe which is very frequently observed, hallux valgus being the almost universal cause. The part is swollen and tender upon pressure, and if suppuration occurs the pain is severe, and cellulitis is apt to develop, involving the surrounding parts, or the joint may be involved, caries of the bones of the articulation resulting.

Treatment.—If suppuration has not occurred, the part should be protected from pressure by a circular shield of felt or plaster; if suppuration has taken place, the part should be incised and drained, and if the joint is found diseased it should be curetted and dressed with an antiseptic dressing; if malposition of the toe exists, its position should be corrected by excision of the joint or by an osteotomy of the metatarsal bone of the toe a little distance above the joint.

CHAPTER XX.

SURGERY OF THE OSSEOUS SYSTEM.

INJURIES OF BONE.

Contusions of Bone.—Bones in exposed positions are often subjected to severe contusions; those which are deeply seated may receive similar injuries, as in the case of gunshot contusion of bone. Contusion of bone is followed by more or less swelling of the periosteum, due to extravasation of blood, which may also occur in the Haversian and medullary canals; later there may develop swelling from inflammatory exudates. Simple contusions of bone are usually not serious injuries, unless tubercular or pyogenic organisms reach the injured part, in which case tubercular ostitis or an acute suppurative periostitis and ostitis may develop, causing extensive destruction of bone as well as marked constitutional disturbance.

Treatment.—Simple contusions of bone should be treated by rest of the involved part, by the application of cold by means of an ice-bag, by compression to limit the amount of extravasation, and later by moist dressings, elastic compression, and massage. Under this form of treatment the tenderness and swelling usually subside rapidly. If, however, suppuration occurs at the seat of contusion, evidenced by elevation of temperature, pain, increase in the swelling, and fluctuation, necrosis of the bone is apt to occur unless very prompt treatment is instituted. Every surgeon has seen suppuration and disastrous results follow contusions of bone, especially in tuberculous subjects. In such cases the skin surrounding the seat of injury should be sterilized, and a free incision made through the tissues down to the bone to evacuate the pus and relieve tension; the wound should then be irrigated with a solution of bichloride of mercury 1 to 2000, or with a solution of acetate of aluminum, and a moist dressing applied. If the incision be promptly made and the wound thoroughly sterilized, the vitality of the bone may not be impaired, and healing may take place rapidly.

Incised Wounds of Bone.—Incised wounds of bone may be inflicted with sharp cutting instruments, such as axes, chisels, and swords, or by pieces of glass, and the injury may vary from an incision into the bone to its complete division, or a portion of the bone with its periosteum may be turned off as a flap.

Treatment.—In the treatment of incised wounds of bone great care should be taken to render the wound aseptic, the skin being carefully sterilized and the wound irrigated with an antiseptic solution; fragments of bone attached to the periosteum should be pressed back into place, and if possible a few catgut sutures introduced into the periosteum to fix them. If the bone be completely divided, the ends should be drilled, and silver

wire, catgut, or kangaroo tendon sutures introduced to obtain primary fixation. After replacing and fixing the fragments the external wound should be closed and covered with an antiseptic or a sterilized dressing. Incised wounds of the fingers completely dividing the phalanx and completely or incompletely dividing the attached soft parts should be treated by accurately replacing the parts and sustaining them in position, applying an antiseptic dressing and a fixation splint.

FRACTURES.

A fracture may be described as an injury of bone in which, by sudden flexion, contusion, or torsion, there results a solution in its continuity. Fractures are accidents of great frequency. Bruns states that of three hundred thousand cases of injury taken to the London Hospital in thirty-three years, one-seventh were fractures. They occur three times more frequently in males than in females. Between the ages of fifty and seventy years both sexes are about equally affected; in middle life they are much more frequent in males. No injuries require more care in diagnosis and treatment than fractures, as they are a prolific source of litigation between the patient and the medical attendant, since it is unusual to have a cure result in a case of fracture, in spite of the greatest skill and care on the part of the surgeon, without more or less deformity, shortening, or thickening of the bone at the seat of fracture, and in the case of fracture near or involving the joints a certain amount of restriction of the motions of the joints is apt to follow. The result of the injury may also be largely due to the conduct of the patient, who may disregard the instructions of the medical attendant and may use the part or disturb the dressings. In view of these facts, the practitioner in taking charge of a case of fracture should insist upon implicit obedience to his orders on the part of the patient, and should state to the patient and his friends the probability of the occurrence of more or less deformity or loss of function, if the case be one in which such a result is likely to occur, and if he finds that his orders are not strictly obeyed he should withdraw from the case. In complicated fractures where a good functional result is not likely to follow, it is also wise for the practitioner to fortify his position by a consultation with another medical man.

Causes of Fractures.—The causes of fractures are predisposing and exciting.

Predisposing Causes.—Position.—The long bones of the extremities, from their shape, mobility, and exposed position, from their having powerful muscles inserted into them, and from their being used to protect the trunk from injury, are more exposed to fracture than the short and irregular bones.

Form.—The form of the bone is a predisposing cause of fracture, the long partially curved bones having less resisting force than the short, flat, or irregular bones; increase in the length of a bone without a corresponding increase in its thickness is also a predisposing cause of fracture.

Structure.—The strength and elasticity of a bone depend upon its structure; the more elastic a bone is, the less likely it is to be fractured.

Pathological Conditions.—Atrophy of bone, from disuse or disease, may weaken it and make it more liable to fracture. Certain inflammatory affections of bone, necrosis and caries, as well as malignant diseases, may be predisposing causes of fracture. *Rachitis* is a common predisposing cause. Absorption of a portion of a bone by the pressure of an aneurism or a tumor may also be a predisposing cause of fracture.

Nerve affections, producing atrophy or degeneration of bone, may also predispose to the production of fracture.

Exciting Causes.—The principal exciting causes of fracture are external violence and muscular action. *External violence* is by far the most frequent cause of fracture, but it is probable that muscular action in many cases, by fixing the parts, causes fractures to result from falls which otherwise would not occur. *Muscular action* is also a frequent cause of fracture; the patella is often broken by this means, as well as other bones. Muscular action is probably a much more frequent cause of fracture than is generally supposed, for insensible or drunken subjects, whose muscles are relaxed, often have the bones exposed to great violence without the production of fracture. Violence may produce a fracture when applied directly, as when heavy bodies come in contact with the bones, such as the wheels of wagons, or masses of timber, iron, or stone, or the result may occur from violence applied indirectly, as when a fracture of the femur takes place from a fall upon the foot.

Varieties of Fracture.—Fractures may be **complete,** when the line of fracture entirely divides the bone, or **incomplete,** when the whole thickness of the bone is not divided and a portion remains unbroken or bent. (Fig. 321.) The latter variety of fracture is also known as a **greenstick** fracture, and is often seen in the long bones of children.

FIG. 321.

Incomplete fracture of the radius. (Fergusson.)

Fissured Fracture.—This is also a variety of incomplete fracture which is met with in the bones of the skull and in flat bones. In such cases one or more lines of fracture may exist which do not extend over the whole area of the bone.

Simple or Closed Fracture is a fracture in which the separated ends of the bone do not communicate with the air through an open wound.

Compound or Open Fracture.—This is a fracture in which the separated ends of the bone communicate with the air through a wound in the soft parts. (Fig. 322.) The communication with the air may be through the skin or the mucous membrane; the latter condition is generally seen in fractures of the jaw.

Comminuted Fracture.—This is a fracture in which there are several fragments, the lines of fracture intercommunicating. (Fig. 323.) When the fragments are exposed to the air through a wound in the surrounding tissues, such a fracture is known as a *compound comminuted* fracture.

Multiple Fracture.—This is a fracture in which the bone is separated at a number of points, and the lines of fracture are distinct from one another.

Complicated Fracture.—This is a fracture in which, in addition to the separation of the bone, there is some serious injury to the surrounding or contiguous structures. Thus, a fracture may be complicated by a disloca-

Fig. 322.

Compound fracture of the tibia. (Miller.)

tion or by the rupture of an important artery, nerve, or vein near the seat of injury, or by the destruction of a neighboring joint, or by a serious flesh wound, burn, or scald which does not communicate with the bone at the seat of injury.

Impacted Fracture.—In this form of fracture one fragment is driven into and fixed in the other. (Fig. 324.)

Sprain Fracture.—This is a form of fracture described by Callender, which is sometimes observed about the joints, particularly the wrist and the ankle, and consists in the

Fig. 323.

Comminuted fracture of the femur. (Agnew.)

Fig. 324.

Impacted fracture of the neck of the femur. (Miller.)

Fig. 325.

Fracture or separation of the upper epiphysis of the humerus. (Moore.)

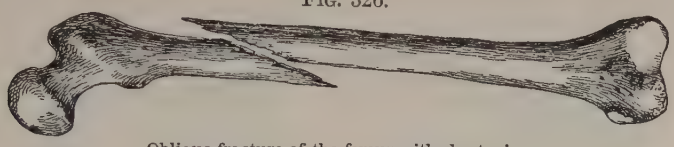
tearing off of a ligament from the bone with a thin shell of its bony insertion.

Epiphyseal Fracture or Separation.—This injury, which consists in the tearing off of the epiphysis from the diaphysis of a bone, the separa-

tion occurring at the cartilaginous line of union, is usually classed among fractures. (Fig. 325.) The injury generally occurs in persons under twenty years of age, and is said to interfere markedly with the subsequent growth of the bone.

Direction of Fracture.—In cases of fracture the line of separation may be oblique, transverse, longitudinal, or spiral.

FIG. 326.

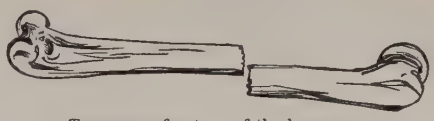


Oblique fracture of the femur with shortening.

Oblique Fracture.—This is the most common variety of fracture, and is one in which the line of separation is at an acute angle to the long axis of the bone. (Fig. 326.)

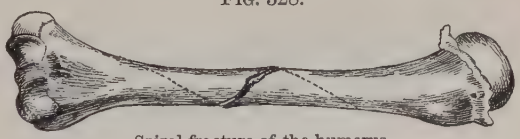
Transverse Fracture.—In this variety of fracture the line of separation is at right angles to the long axis of the bone: it is much less commonly met with than oblique fracture. (Fig. 327.) The ends of the bone in transverse fracture are often dentated, preventing the occurrence of much displacement. Transverse fractures are often seen in the short and flat bones and in the spongy ends of the long bones, and are not infrequent in the shafts of the long bones in children.

FIG. 327.



Transverse fracture of the humerus.

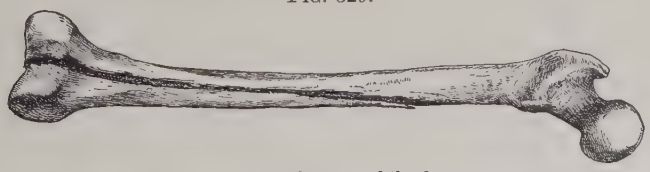
FIG. 328.



Spiral fracture of the humerus.

Spiral Fracture.—This form of fracture is occasionally seen in the long bones, and consists of a fissure which winds around the shaft more or less obliquely. (Fig. 328.) It is most often observed in the tibia, femur, and humerus, and results from violent torsion of the bone; experiments with fresh bones have demonstrated that spiral fractures could be so produced.

FIG. 329.



Longitudinal fracture of the femur.

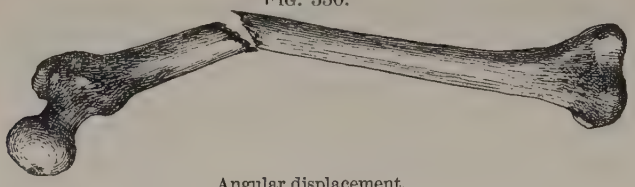
Longitudinal Fracture.—In this variety of fracture the line of separation runs in the general direction of the long axis of the bone. (Fig. 329.)

This form of fracture is very rare in the long bones, but was formerly met with as the result of gunshot injury.

Displacement in Fracture.—The principal displacements in fracture are angular, lateral, rotatory, longitudinal, and displacement by depression.

Angular Displacement.—This form of displacement, in which the fractured ends of the bone are at an angle with each other (Fig. 330), is

FIG. 330.



Angular displacement.

very common, and results from weight and muscular action; it is possible to have it well marked even in incomplete fractures, and it is observed in transverse fractures, as well as in oblique fractures combined with overlapping of the fragments.

Lateral Displacement.—This is usually observed in transverse fractures, consisting in the end of one fragment resting in part against the other, and may be associated with a certain amount of rotatory displacement.

Rotatory Displacement.—This consists in one fragment being turned upon its axis. (Fig. 331.) This displacement is observed in fractures of

FIG. 331.

Rotatory displacement.

the bones of the extremities, and is due to the weight of the limb and to muscular action. In fractures of the femur and of the bones of the leg it is a very common deformity.

Longitudinal Displacement.—This is a very common form of displacement in fractures which take place in the direction of the length or long axis of the bone. In oblique fractures, muscular action and the line of fracture favor the sliding of one fragment past the other, producing *overlapping* or *shortening*. (Fig. 326.) Muscular action may also produce longitudinal separation of the fragments in fractures, as is seen in cases of transverse fracture of the patella and of the olecranon process.

Depression.—This displacement consists in one or more fragments being depressed below the general surface of the bone. This deformity is seen in fractures of the flat bones, such as the skull and the scapula, as well as in comminuted fractures of the long bones.

Signs of Fracture.—The most important signs of fracture, the presence of which usually enables the surgeon clearly to demonstrate its exist-

ence, are deformity, preternatural mobility, loss of function, pain, crepitus, and muscular spasm.

Deformity.—This is a sign of fracture which may arise from swelling of the soft parts or displacement of the fragments, and is usually the one which first attracts the attention of the surgeon. In the majority of cases of fracture the injured part loses its natural appearance, and this change can usually be clearly seen upon comparing it with the corresponding part on the sound side. The deformity in fracture arises from external force, which drives the fragments into unnatural positions, and from muscular action; in fractures of the long bones, where bony resistance is lost, marked contraction of the muscles occurs, producing extensive deformity. The deformity due to swelling may arise early from the extravasation of blood, or later from inflammatory exudates when the process of repair has been established.

Deformity in fracture is recognized by inspection, measurement, and palpation. In taking measurements to ascertain the amount of shortening, corresponding measurements should be made upon the injured and upon the sound side. The various bony prominences are used as fixed points; in the lower extremity the anterior superior spine of the ilium, the edge of the patella, the condyles of the femur, and the malleoli are frequently used, while in the upper extremity the acromion process, the epicondyles, the olecranon process, and the head of the radius are generally employed.

Preternatural Mobility.—This is a very important sign of fracture, which can be obtained except in a few instances. The existence of mobility in the shaft of a bone can be due to no other cause than fracture. In fractures very near articulations it is often difficult to separate motion at the seat of fracture from the motion at the joint, and here we have to depend upon other signs. Impaction at the seat of fracture prevents this sign from being elicited. In examining a patient to detect mobility, the manipulations should be made with great gentleness, to avoid giving the patient pain, as well as to prevent injury to the surrounding structures by the roughened ends of the fractured bone.

Loss of Function.—This is usually a valuable sign of fracture, as there is generally inability to execute the normal movements of the part; a patient suffering from a fractured leg or thigh is not able to support his weight upon it, and the same may be said as to loss of function in the bones of the upper extremity. Occasionally, however, cases are observed in which a patient will walk with a fractured leg in which there is little displacement of the fragments. In these cases it is probable that there has been impaction of the fragments, which keeps up the continuity of the bone.

Pain.—The pain in fracture is usually of a severe, sharp character, but it varies much with the bone involved, the character of the fragments, and the amount of movement in the parts after the injury.

Muscular Spasm.—This is a valuable sign of fracture, and is produced by irritation of the muscles and nerves by the irregular fragments of the fractured bone. It is intermittent, is accompanied by pain, and is apt to follow slight movements. It is a symptom which is often observed where many of the other signs of fracture are absent, and is especially valuable

as a diagnostic sign in fractures of bones deeply seated and surrounded by thick masses of muscular tissue, as the femur and the humerus.

Crepitus.—This sign of fracture is produced by the grating of one broken surface against the other, and the conditions which favor its production are mobility at the seat of fracture, with contact of the fragments. If impaction of the fragments has occurred, or if there are interposed between them shreds of fascia or muscles, crepitus cannot be elicited. Crepitus is affected by the density of the bone, being more marked in fracture of the shaft of a long bone, and less distinct in that of the cancellous ends of a long bone, in fracture of a short bone, and in an epiphyseal separation. The crepitation observed in cases of teno-synovitis and inflammation of bursæ and the cartilages of joints is sometimes confounded with the crepitus of fracture, but it is a softer variety of crepitus, resembling the sensation which is felt upon rubbing two pieces of leather together, and is not accompanied by the other signs of fracture. In eliciting crepitus the surgeon should make extension of the injured parts, and gently rotate them, at the same time grasping the seat of fracture firmly with the hand, or the fragments may be tilted by pressure with the fingers. Although it is a valuable sign of fracture, it is not justifiable to use any violent manipulation for its production: the same gentleness should be exercised in eliciting this symptom as in obtaining that of preternatural mobility, for violent movements give the patient pain, and may be followed by injury of the surrounding soft parts. The fact, therefore, that crepitus cannot be obtained, as before stated, does not prove that a fracture is not present.

Discoloration.—This sign in fractures may arise from two sources—from the hemorrhage following rupture of vessels in the subcutaneous cellular tissue, which is apparent a few hours after the injury, and from the blood which escapes from the bone and deep structures at the seat of fracture, causing discoloration of the overlying skin some days after the injury. As a similarly developed discoloration may arise from contusions of deep structures or from sprains, we do not, therefore, consider it an important diagnostic sign of fracture.

Diagnosis.—The diagnosis of fracture is often simple, while at other times it is extremely difficult, and is made by eliciting and observing the symptoms just mentioned. A very valuable aid to the diagnosis of fracture has recently been introduced in the use of the Röntgen or X rays, which are often of the greatest service in proving the existence and location of fracture in obscure cases. The application of this method of examination is likely to add much precise information to our knowledge of fractures.

Examination of a Fracture.—In cases of fracture it is always well to make a systematic examination, and the best time to make this examination is as soon as possible after the fracture has taken place, for if it is delayed for some time there will usually be so much swelling that many of the important signs cannot be obtained. As before stated, the injured part should be compared with its fellow, and the bony prominences should be located as guides to displacement. The part should then be firmly extended, and gentle manipulations made to obtain mobility and crepitus. The use of an anæsthetic is often of the greatest value in the exam-

ination of fractures, as by its employment the patient is saved much pain, the muscular resistance is done away with, and the surgeon can accurately locate the seat and direction of the fracture and coaptate the fragments. We think it a wise rule to administer an anæsthetic for the examination of any case of obscure fracture or one near or involving a joint. The only possible disadvantage in its use arises from the struggles of the patient, which may cause movement of the fragments with injury to the surrounding parts; this can be guarded against by having the part firmly held or fixed by splints while the anæsthetic is being given. The fact that the examination is made without pain to the patient should not lead the surgeon to make forcible movements to elicit mobility or crepitus, for there is the same risk of damage to the soft parts as without anæsthesia, so that all manipulations should be made with extreme gentleness.

Every surgeon has met with cases in which after the most careful examination he was unable to determine the existence of fracture, although he was morally certain that such an injury existed; the safe rule of practice is to consider the case one of fracture and treat it accordingly.

TREATMENT OF FRACTURES.

Various methods of treatment of these injuries have at different times been advocated and practised, but the one which has been most widely employed is that which consists in approximation of the fractured ends of the bone by extension and manipulation and their retention in position by splints or mechanical appliances and by position. *Prolonged fixation* has long been considered the most important measure in the treatment of these injuries. Recently the method of massage introduced by Lucas-Championnière and the ambulatory method applied to the treatment of fractures of the lower extremity have attracted some attention.

Massage in the Treatment of Fractures.—Lucas-Championnière advocates and practises immediate and continuous massage in the treatment of fractures, and holds that by its use pain is diminished, the repair of bone hastened by the profuse deposit of callus, and the atrophy of muscles and stiffening of joints avoided.

Massage is applied as soon as possible after the fracture has occurred, and consists in manipulations with the thumb, the fingers, or the whole hand. The limb is held by an assistant and extension is made, or it is placed upon a firm pillow or a sand cushion. The manipulations should be made in the direction of the muscular fibres and of the blood-current, and firm pressure should not be made directly over the seat of fracture.

Massage should be practised for from fifteen to twenty minutes daily, and no retention apparatus should be applied in the intervals unless there is marked tendency to displacement of the fragments, when some form of retention apparatus or splint may be used. These manipulations should be continued for some weeks, until union is firm at the seat of fracture. Massage has also been combined with the ambulatory method of treatment of fractures of the lower extremity. This method of treating fractures by massage may be said to be still on trial, sufficient experience not yet having accumulated to prove that it possesses marked advantages over the gener-

ally adopted method of treatment by immobilization. It is possible that the best results will follow a judicious combination of the two methods.

Provisional Dressings of Simple Fractures.—It usually happens that a fracture occurs at a locality more or less distant from the place where its treatment is to be conducted, and the transportation of the patient and the temporary dressing of the fracture are therefore matters of great importance.

In simple fractures of the *upper extremity* the clothing need not be removed; the arm should be bound to the side by some article of clothing, or supported in a sling made from handkerchiefs or the clothing, and the patient can then usually ride or walk without inconvenience and without injury to the parts in the region of the fracture. When, however, the bones of the lower extremity or of the trunk are involved, the transportation of the patient is a matter of much greater difficulty. When the bones of the *trunk* are involved, the part should be surrounded by a binder, firmly pinned or tied, made from the clothing or from sheets or any other strong material which may be at hand. When the bones of the *lower extremity* are involved, if the fracture be a simple one, the clothes need not be removed, and the motion of the fragments at the seat of fracture should be prevented by applying to the sides of the limb, extending above and below the seat of fracture, strips of wood, shingles, or pasteboard, bundles of straw, strips of bark taken from trees, or bundles of twigs, these being held in place by handkerchiefs or strips torn from the clothing. Umbrellas, canes, or broomsticks applied in the same manner may be employed, the object of all of these dressings being to secure temporary fixation of the fragments, or the injured limb may be bandaged to the sound one. If the fragments are not fixed in some way, but are allowed to move about during the transportation of the patient, much damage may result to the soft parts around the fractured bone, and simple fractures may become compound ones by the bones being forced through the skin, the discomfort and danger to the patient being thus much increased.

Reduction or Setting of Fractures.—Before attempting the reduction of a fracture it is necessary to remove the portion of the clothing covering the injured part, and in doing this the part should be firmly held, extension being made while an assistant either cuts away the clothing, or rips it so that it can be removed so as freely to expose the parts.

Reduction or setting of fractures consists in bringing the fragments by extension and manipulation as nearly as possible into their normal position, and is accomplished by making extension, counter-extension, and manipulation with the hands, care being taken to use no more force than is necessary to attain this object. The principal obstacle to the reduction of fractures is muscular spasm, which may be overcome by placing the parts in such a position as to relax the muscles which cause the displacement, or by the administration of an anæsthetic. Reduction in cases of fracture should be effected as soon as possible after the occurrence of the injury, and as soon as the surgeon is prepared to apply the dressings which are to be employed in the future treatment of the case. Reduction at an early period is less painful to the patient and is accomplished with more ease by the surgeon

than at a later period, when marked swelling or inflammation is present at the seat of fracture. When the reduction of the fracture has been accomplished, the fragments are retained in position by the application of various splints or dressings.

Materials and Appliances used in the Dressing of Fractures.—**The Fracture-Bed.**—Many ingenious and complicated forms of fracture-bed have been devised and used, but they are now not much employed. In the treatment of fractures of the trunk or of the lower extremity it will be found most convenient to use a single bed, not over thirty-two to thirty-six inches in width, with a firm hair mattress. It is not necessary that this be perforated, as a bed-pan can usually be slipped under the patient without difficulty. An ordinary shallow tin plate, covered with a piece of old muslin, to receive the fecal evacuations, may be substituted for the bed-pan, and will be found in many instances more satisfactory, especially in the case of children.

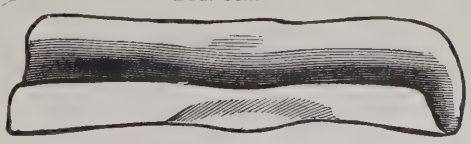
Splints.—After the reduction of the fragments in cases of fracture they are usually retained in position until union has occurred by the use of splints held in position by means of bandages or strips of muslin. Splints may be made of wood, metal, binders' board, leather, felt, paper, and plaster of Paris.

Wooden Splints.—The simplest and cheapest splints are made from wood: white pine, willow, and poplar are the best materials for their construction, being sufficiently strong and at the same time light. These splints are made from one-eighth to one-quarter of an inch in thickness, and may be employed in the form of straight or angular splints. Wooden splints before being applied should be well padded with cotton, wool, oakum, or hair. We do not think the curved wooden splints sold by the instrument-makers are to be recommended, as a rule, for unless the surgeon has a large number to select from it is rarely that a splint can be obtained to fit accurately any individual case.

Metallic Splints.—Splints constructed of tin or wire are sometimes used in the treatment of fractures, and if carefully fitted and padded may serve a useful purpose.

Binders' board or pasteboard is an excellent material from which to construct splints. It is first soaked in boiling water, and when sufficiently soft is padded with cotton or a layer of lint and moulded to the part. (Fig. 332.) It may be secured in position by a bandage. As it becomes dry it hardens and retains the shape into which it was moulded. *Undressed leather* is also a good material from which to construct splints, and is applied by first soaking the leather in hot water, and, after padding it with cotton or lint, moulding it to the part and retaining it in position by a bandage; or it may be moulded upon a plaster cast taken from the part.

Fig. 332.



Binders' board splint.

Felt, made from wool saturated with shellac and pressed into sheets, is also a satisfactory material from which to construct splints. It is prepared

for application by heating it before a fire until it becomes pliable, or by dipping it into boiling water.

Plaster of Paris, starch, chalk, gum, or silicate of potassium or of sodium may be employed in the construction of splints, either movable or immovable, for the treatment of fractures. Of these, the plaster of Paris dressing is the one which is now most generally employed in the treatment of fractures.

Fracture-Box.—This is a form of splint used in the treatment of fractures of the lower extremity, and consists of a board eighteen or twenty inches in length and eight inches in width, with a foot-board secured to its lower extremity, and sides which are secured by hinges, which allow them to be raised or lowered. (Fig. 333.) When a fracture-box is used it is padded by placing in it a soft pillow. A fracture-box of greater length is required for the treatment of fractures about the knee-joint.

Fig. 333.

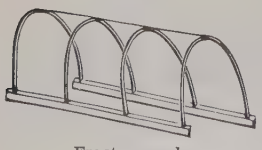
Fracture-box.

Bran, Sand, or Junk Bags.—These bags are frequently employed in the treatment of fractures of the femur. The bag, made from a piece of unbleached muslin from three to five feet in length and fourteen and a half inches in width, is filled with dry sand, bran, hair, or straw, and its mouth closed by stitches or by tying with a string.

Bandages.—Bandages used in the treatment of fractures are ordinarily made of muslin, being employed to retain splints in place, and sometimes applied directly to the injured part before the application of splints, to control muscular spasm and limit the amount of swelling. When a bandage is used for this purpose it is known as a *primary roller*. The primary roller is sometimes of the greatest service in the dressing of fractures, in controlling muscular spasm, but when used the case should be under constant observation, and it should never be used under flat splints, for if swelling occurs after its application it will require prompt removal.

Compresses.—These are employed in the treatment of fractures to retain fragments in position or to make localized pressure over certain points, and are made from a number of folds of lint, cotton, or oakum. Compresses are held in position by strips of adhesive plaster or by a few turns of a roller bandage. They are sometimes employed to protect bony prominences from the pressure of the splints. This purpose is often better effected by the use of small pieces of soap plaster spread on chamois, soft leather, or kid, and fitted around the prominent points.

Fig. 334.



Fracture-rack.

A **Rack** or **Cradle** made of wire or wooden hoops is often employed to support the weight of the bedclothes in the treatment of fractures of the lower extremity. (Fig. 334.)

Evaporating or Anodyne Lotions.—Many surgeons in cases of fracture, especially those involving or situated near joints, employ evaporating lotions, such as lead water and laudanum or muriate of ammonia and laudanum; lint saturated with one of these lotions is applied to the skin in the

region of the fracture. Other surgeons think that their use causes irritation of the skin and delays the process of repair in the fracture, and therefore strongly condemn their employment. We have never seen any evil results arise from their use, and often employ them in fractures near or involving the joints, but use them only for a few days.

An ointment of ichthyol, 1 part, and lanolin, 3 parts, spread upon lint and applied over the part, will often prove a satisfactory dressing in cases of fracture accompanied with pain and swelling, where the surgeon does not wish to use any of the lotions before mentioned. A layer of cotton wrapped around the part at the seat of fracture may be employed in the place of the previous dressing before the application of the splints.

Repair of Fractures is considered on page 74.

FRACTURES OF SPECIAL BONES.

Fractures of the Nasal Bones.—Fractures of the nasal bones are usually produced by direct force, and the line of fracture may be either transverse or oblique; the former are most common, and the seat of fracture is usually about half an inch above the lower margin of the bone; the upper and frontal portions of these bones are very thick and strong and will resist a great degree of force. The line of fracture may extend to the superior maxilla or to the cribriform plate of the ethmoid bone; the latter is a dangerous complication because of the liability to septic meningitis. These fractures may be comminuted or compound, either through the skin or the mucous membrane.

Deformity.—As the soft parts swell quickly after the injury, the deformity following this fracture is often masked unless the case is seen early. The deformity consists in lateral displacement, the nose being turned to one side, or the fragments may be depressed.

Symptoms.—The symptoms of fracture of the nasal bones are epistaxis, deformity, mobility, and crepitus. If there is flattening or lateral deviation of the nose, even though crepitus is not discovered, the existence of fracture may be assumed.

Complications.—Hemorrhage is often at first profuse in fractures of the nasal bones, but usually subsides quickly; however, cases are occasionally seen in which the hemorrhage continues and is so severe that plugging of the nasal cavities with antiseptic gauze may be required.

Emphysema.—In compound fractures of the nasal bones in which the mucous membrane and the periosteum have been torn, air may pass into the cellular tissue of the face. This is not a serious complication, as the air gradually disappears as the healing of the fracture advances.

Treatment.—The treatment consists in replacing the fragments, if displacement exists, by manipulation with the fingers over the seat of fracture, and by pressure made from within the nostrils by a probe or steel director, the end of which is wrapped with a little cotton. Before resorting to any manipulation within the nasal cavities the mucous membrane should be thoroughly cocainized, to render the operation painless. When there is depression of the fragments or displacement of the septum, after correcting the deformity by raising the depressed fragments or bending the septum into place with a

director, the parts may be held in position by packing the nasal cavities firmly with strips of antiseptic gauze around pieces of rubber catheter introduced into the lower nasal fossa. In lateral displacement of the nasal bones from fracture, after reducing the displacement, a small compress held over the fragments by strips of adhesive plaster will be the only dressing required; indeed, in many cases when the displacement is once corrected it is not apt to recur and no dressing is required. In cases where the fragments are depressed and cannot be held in position by packing the nares with gauze, a sterilized steel needle may be passed through the skin below them and brought out upon the other side of the nose, and a strip of adhesive plaster passed over the bridge of the nose and fastened to the ends of the needle to steady the fragments; the needle should remain in position from eight to ten days.

Compound fractures of the nasal bones through a wound in the skin are usually not serious injuries; detached fragments should be removed, but fragments having vital attachments should be pressed back into position and the wound should be covered with an antiseptic dressing. Compound fractures involving the mucous membrane of the nose are more serious injuries; the nasal cavities should be irrigated with a mild antiseptic solution and packed with iodoform gauze.

Fractures of the Upper Jaw.—These fractures usually result from force directly applied, and may involve the body, the nasal process, or the alveolar process. As these fractures are usually the result of the application of great force, comminution of the bone is not uncommon, and they are often associated with fracture of other bones of the face. If the injury is confined to the bones of the face, although there may be numerous fractures and extensive comminution, recovery usually follows, with more or less deformity.

Complications.—Fractures involving the nasal process with laceration of the mucous membrane may be followed by emphysema of the face, or, as the nasal process contributes to the formation of the lachrymal canal, its injury may be followed by obstruction to the passage of tears. Fracture of the superior maxillary bone may also be complicated with fracture of the base of the skull. The infra-orbital nerve may be injured in fractures near the orbital plate, which may give rise to neuralgia or sensory paralysis. Hemorrhage in compound fractures of the superior maxilla may be profuse.

Treatment.—In the treatment of fractures of the upper jaw all fragments and splinters of bone having vital attachments should be replaced, if any teeth have been displaced they should be replaced, and if there is comminution of the alveolus the teeth and the separated fragments may be fastened together by fine silver wire to fix and hold them in place; the lower jaw should then be brought in contact with the upper jaw to act as a splint, and the jaws should be secured together by the application of a Barton's bandage. (Fig. 335.) Interdental splints made of cork, with grooves to fit the teeth, or of gutta-percha, are also sometimes employed in the dressing of these fractures. The patient should not be allowed to move the jaw in mastication, and should be nourished with liquid and semi-solid food. The bandage should be removed every second or third day. These fractures are usually firmly united at the end of four or five weeks.

Fracture of the Malar Bone.—Fracture of the malar bone is usually the result of direct force, and unless the antrum is broken into there will not be much displacement. These fractures are often associated with a fissure which passes into the orbit, terminating in the sphenoidal fissure.

Symptoms.—The signs of this accident are pain, discoloration, occasionally mobility and crepitus, and some degree of deformity. If the line of fracture extends into the orbit, extravasation of blood at the outer canthus of the eye is frequently present. If the infra-orbital branch of the fifth pair of nerves is involved, there may be loss of sensation in some of the anterior teeth and in the gums, and also in the ala of the nose.

Treatment.—If there is displacement, it should be corrected by pressure applied inside of the mouth or outside of the cheek. If the body of the bone is depressed by being driven into the antrum, if a wound is present the fragment may be raised by means of an elevator, or if no wound is present a screw elevator may be introduced through a puncture in the soft parts, and it may be raised by this means; if there is no marked displacement, a compress should be applied over the seat of fracture and held in position by adhesive strips.

Fig. 335.

Dressing for fracture of the upper jaw.

Fracture of the Zygomatic Arch.—This bone is occasionally broken, but the accident is a rare one. It is usually produced by direct force, and is apt to involve that portion which is attached to the temporal bone, which is the weaker part.

Symptoms.—The swelling and contusion of the soft parts usually mask the condition, and, unless there is great deformity or irregularity, it is often difficult to diagnose this fracture. If the fragment is depressed, it may press upon the masseter muscle or the tendon of the temporal muscle, and interfere with the movements of the lower jaw.

Treatment.—In cases of fracture of the zygomatic arch without displacement, the jaws should be fastened together with a Barton's bandage to secure rest of the masseter and temporal muscles. When the fragment is displaced and there is involvement of the tendon of the temporal muscle, if no wound is present exposing the seat of fracture it may be necessary to make an incision, introduce an elevator, and raise the fragment into its normal position, or the fragment may be raised by a loop of strong silver wire passed beneath it with a curved needle.

In fractures of the malar bone and zygomatic arch, when the deformity has once been corrected there is little tendency to its reproduction, and union is usually quite firm at the end of three weeks.

Fractures of the Lower Jaw.—These fractures are generally produced by direct force applied either to the side of the bone or upon the chin, and frequently result from falls upon the chin, from blows, or from the kicks of horses. Fractures of the inferior maxillary bone may involve

the body, the ramus, or the processes. A fracture involving the body of the bone may occur at any point from the angle to the symphysis, and may involve the entire thickness of the bone or be confined to a portion of the alveolar process. Fractures of the body of the bone are usually compound through the mucous membrane of the mouth. Multiple fracture of the body of the bone is not an uncommon accident. The most common seat of fracture is near the anterior dental foramen (Fig. 336), which is sometimes associated with a fracture near the angle on the opposite side. Fracture may also occur at the symphysis, through the ramus, the neck of the condyloid process, or the coronoid process.

FIG. 336.

Fracture of the lower jaw. (Malgaigne.)

Symptoms.—The symptoms of fracture of the lower jaw are pain and inability to move the jaw, mobility, crepitus, and deformity: the latter depends largely upon the situation of the fracture. When the fracture is at the symphysis one fragment will usually be a trifle higher than the other, and the line of the dental arch will be displaced. In fractures in front of the masseter muscle—that is, near the anterior dental foramen—the posterior fragment will generally be found external to the anterior fragment, the overlapping being produced by the action of the digastric muscle on the injured side and the influence of the internal pterygoid and the external portion of the masseter muscle on the sound side; these two forces act upon the anterior fragment, while the internal pterygoid and the deep masseter muscle affect the posterior fragment. When the ramus of the lower jaw is broken there is generally very little displacement of the fragment, from the fact that the masseter and pterygoid muscles cover the part and act as splints. When the neck of the condyloid process is broken there is usually deep-seated pain in front of the ear, aggravated by movements of the jaw.

Complications.—It is rare for serious complications to follow fractures of the inferior maxillary bone. The inferior dental nerve appears usually to escape injury, but occasionally bleeding has been observed from the ears, from force transmitted to the external auditory canal through the condyles of the jaw.

Necrosis.—As these fractures are usually compound through the mouth, necrosis frequently occurs and retards repair.

Treatment.—In fractures of the *body* or *ramus* of the lower jaw, the deformity should be reduced by manipulation, and the lower jaw should be brought up against the teeth of the upper jaw and fixed in this position by the application of a Barton's bandage. (Fig. 335.) A cup-shaped splint of binders' board may be moulded to the chin and held on by the Barton's bandage to give additional fixation to the parts. If there is very great displacement of the fragments, this can be remedied and the fragments secured in their natural position only by exposing the fragments, drilling them, and securing them in position by the application of one or two heavy wire, catgut, or kangaroo tendon sutures. Where the alveolar process only is separated, this should be pushed back into place, and by wiring together

the teeth of the fragments they may be held securely in position. The patient should be fed upon liquid or semi-liquid diet until there is union at the seat of fracture.

The dressing should be changed at intervals of two or three days, and can usually be permanently removed after five or six weeks. In extensive *compound* fractures of the jaw it is often advisable to pack the wound carefully with iodoform gauze, which requires removal at intervals of two or three days.

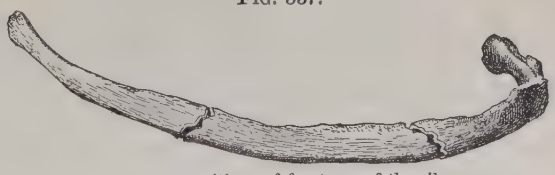
Fracture of the Hyoid Bone.—The hyoid bone from its position is not often fractured, yet occasionally this accident has occurred as the result of blows upon the neck, of constriction of the parts, or in hanging.

Symptoms.—The most marked symptom of this accident is pain in the submental region, which may be very severe, and is aggravated by movements of the neck or of the tongue; swallowing is also accompanied by pain, and crepitus may sometimes be obtained. Displacement of the fragment can best be detected by introducing the finger into the pharynx.

Treatment.—If there is displacement, this should be reduced by introducing one finger into the pharynx, and with the fingers upon the outside of the neck, over the position of the bone, pushing the fragment outward and forward. The patient should abstain for a few days as far as possible from moving the jaw and from swallowing. The head and neck should be fixed by sand-bags. If inflammatory symptoms are present, active local treatment should be employed. If cough is a prominent symptom, it should be controlled by opium. A splint of pasteboard or leather moulded to the anterior surface of the neck has been used in some cases with advantage. Rectal feeding and rest in bed should at the same time be employed.

Fractures of the Ribs.—These fractures are very frequent, and may occur at all ages, but are most common in middle and advanced life. In children the mobility and elasticity of the thoracic walls cause this injury to be much less frequent. Fractures of the ribs may be caused by blows, falls, or the passage of heavy bodies over the chest, or by the chest being caught between compressing forces, and are apt to occur in the anterior or the posterior portion of the rib. (Fig. 337.) The ribs most frequently broken are those from the third to the eighth; the first and second ribs are seldom broken. The displacement in fractures of the ribs is usually slight, being prevented by the intercostal muscles and aponeuroses, although in fractures produced by direct violence there may be an inward displacement of the rib, causing injury of the lung.

FIG. 337.



Common positions of fractures of the ribs.

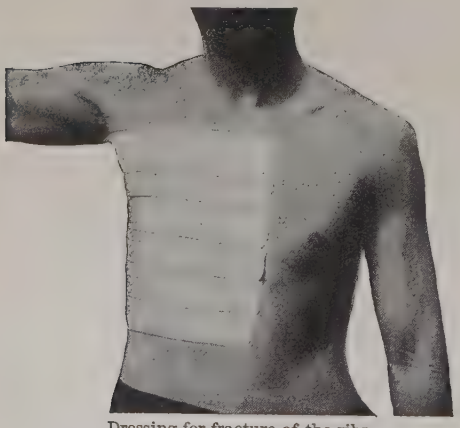
Complications.—The principal complications following fractures of the ribs are injury of the pleura or lung, producing hemorrhage, pneumonia, and emphysema, or laceration of the intercostal vessels followed by profuse hemorrhage.

Symptoms.—The most prominent symptoms of fractures of the ribs are diminished respiratory movements upon the injured side and pain at the seat of injury, which is increased by any attempt to take a full breath, or by coughing. Crepitus may in many cases be obtained by placing the hand over the seat of injury and directing the patient to take a full breath. When the pleura has been punctured and the lung has been injured, emphysema of the cellular tissues over the region of the fracture can usually be felt, and in cases of injury of the lung hæmoptysis may also be present.

Prognosis.—In uncomplicated cases the prognosis is favorable. In compound fractures, however, or in those which are accompanied by injury of the pleura or the lung, although many cases recover, these injuries are most serious ones.

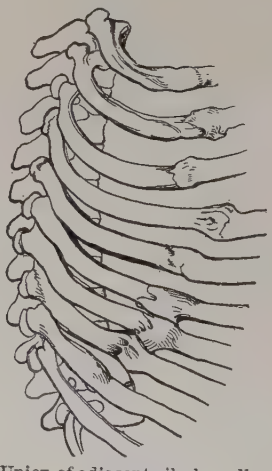
Treatment.—A satisfactory temporary dressing for fractures of the ribs consists in surrounding the chest with a broad binder of stout linen or muslin, which restricts the respiratory movements and relieves the patient's discomfort, but cannot be recommended as a permanent dressing, as it also restricts the respiratory movements upon the uninjured side of the chest. The best permanent dressing for fractures of the ribs consists in enveloping the side of the chest on which the rib or ribs are broken with broad strips of adhesive plaster. (Fig. 338.) For the method of applying these

Fig. 338.



Dressing for fracture of the ribs.

Fig. 339.



Union of adjacent ribs by callus. (Malgaigne.)

strips see page 194. This dressing usually gives the patient much comfort, and the strips need not be removed until they become slightly loosened, usually at the end of a week or ten days, when they should be reapplied in the same manner. The dressing for fractures of the ribs is usually dispensed with at the end of three or four weeks, as repair is well advanced by this time. In the repair of fractures of the ribs a considerable amount of callus is deposited around the seat of fracture, and in fractures of adjacent ribs they may be permanently bound together by callus. (Fig. 339.)

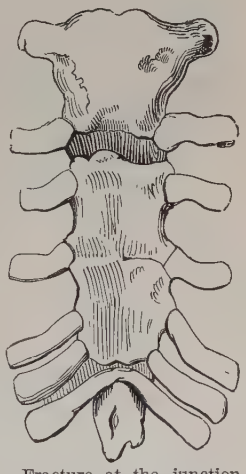
Fractures of the Costal Cartilages.—These fractures are occasionally met with. The cartilages of the seventh and eighth ribs appear to be the ones most commonly broken, and there is generally some outward displacement of either the sternal or the vertebral end of the cartilage. These fractures usually result from force directly applied, or from pressure upon the anterior and posterior portions of the chest. The repair of fractures of the costal cartilages is by a ferrule of bone which surrounds the fragments.

Symptoms.—The prominent signs of fracture of the costal cartilages are pain, which is increased with respiratory movements, deformity, which usually consists in undue prominence at the seat of fracture, mobility, and soft crepitus.

Treatment.—This is the same as that for fractures of the ribs.

Fractures of the Sternum.—Fractures of the sternum are rare injuries, from the fact that the bone has elastic attachments which allow it a considerable amount of motion. As a complete joint sometimes exists between the manubrium and the body, it is often impossible to say whether the injury is a diastasis or a fracture. The seat of fracture may be in the manubrium or at the junction of the latter with the body (Fig. 340), or the body of the bone may be broken, or the xiphoid cartilage may be detached. The displacement in this fracture depends upon the fracturing force. When produced by extreme extension of the body, the lower fragment may be displaced forward and overlap the upper one; when, however, it is produced by flexion, the upper fragment takes a position in front of the lower one. When produced by direct force, the fragments may be driven inward.

Fig. 340.



Fracture at the junction of the manubrium with the body of the sternum. (Malgaigne.)

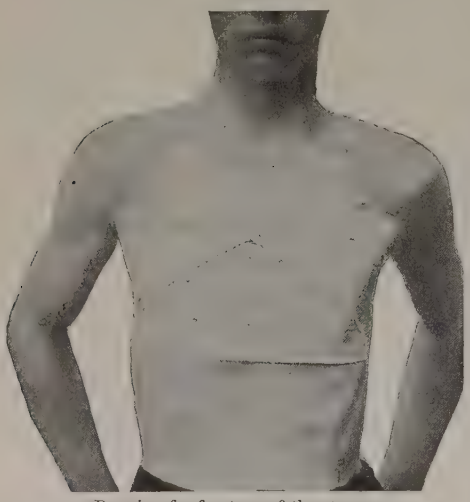
Symptoms.—The most prominent symptom of fracture of the sternum is pain at the seat of injury, which is aggravated by a full respiratory movement, by pressure, or by coughing; crepitus may also be detected, and occasionally emphysema may be observed if the lung has been injured by the fragments. In fractures of the xiphoid cartilage accompanied by inward displacement persistent vomiting is said to be a not infrequent symptom. We had under our care recently a boy who had received a kick in the epigastrium and exhibited an inward displacement of the xiphoid cartilage, in whom this symptom was very prominent for some weeks, but finally disappeared.

Complications.—The most serious complication in fracture of the sternum is inward displacement of the fragments, causing injury of the lung, and accompanied by emphysema, dyspnœa, and expectoration of blood; abscess also may follow fracture of the sternum, which may point at the lateral margins of the sternum or at the xiphoid cartilage. Compound fractures of the sternum may be followed by abscess or necrosis of the bone.

Treatment.—If displacement of the fragments is present in fractures of the sternum, attempts should be made to relieve the displacement by extension or flexion of the body and by manipulation with the fingers. If the de-

formity is not reduced by these manipulations and causes the patient discomfort, the fragments should be exposed by incision, elevated, and wired, if necessary. After reducing the deformity, a compress should be placed over the seat of fracture, and the chest movements should be restricted by applying adhesive straps, two and a half inches in width, which should extend from the middle of the ribs on one side to the same point on the opposite side and should cover in the chest for some distance above and below the seat of fracture. (Fig. 341.) This dressing should be retained for at least four weeks, being renewed at the end of a week or ten days if it becomes loose.

Fig. 341.

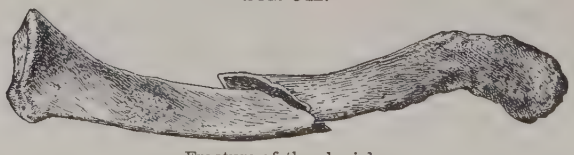


Dressing for fracture of the sternum.

FRACTURE OF THE CLAVICLE.

Fracture of the clavicle is a very common accident, due largely to the exposed position of the bone and its attachment to the sternum and acromion process of the scapula, which latter causes it to receive a part of all forces which are transmitted through the arm or shoulder. Fracture of the clavicle is more common in children than in adults; more than one-third of the cases occur in children under five years of age; and it may exist as a partial or a complete fracture. Bilateral fractures of the clavicle have also occasionally been observed. Fracture of the clavicle may occur at any part of the bone. Fractures of the middle third of the bone are the most common variety, and may be oblique (Fig. 342) or transverse; the former is the most common in adults, the latter in children.

Fig. 342.



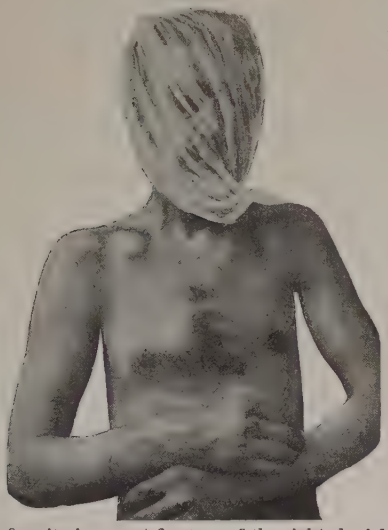
Fracture of the clavicle.

Causes.—Fracture of the clavicle may result from indirect violence, such as falls upon the hands or the shoulder, from crushing force applied to the upper part of the chest, from muscular action, as in striking or lifting, and from direct violence.

Symptoms.—The prominent symptoms in fracture of the clavicle are loss of power, pain upon pressure, and deformity in the line of the bone. The patient usually supports the arm of the injured side at the elbow with the hand of the uninjured arm, and is generally unable to carry the hand of the injured side to the head or to the opposite shoulder; the affected

shoulder is lower and farther forward than its fellow (Fig. 343); crepitus can generally be obtained by grasping the injured arm and carrying it upward, outward, and backward while the fingers are placed over the seat of the fracture. Disability may be very slight in incomplete fractures.

Fig. 343.



Deformity in recent fracture of the right clavicle.

Deformity.—In oblique fractures in the middle third of the clavicle the sternal fragment will be drawn upward by the clavicular fibres of the sterno-

Fig. 344.

Displacement of fragments in fracture of the clavicle. (Agnew.)

cleido-mastoid muscle; the acromial fragment is carried downward by the weight of the shoulder and the action of the serratus magnus, the latissimus dorsi, and the pectoralis major and minor muscles, so that the fragment falls below the level of the sternal fragment: the overlapping is produced by the acromial fragment being drawn inward and forward by the action of the pectoralis major muscle. (Fig. 344.)

Fracture of the outer third of the clavicle is not usually accompanied by much displacement or deformity if it takes place within the limits of the coraco-clavicular ligament, as the attachment of the latter with the periosteum serves to resist displacement of the fragments.

In fracture of the inner third of the clavicle, if situated within the limits of the costo-clavicular ligament, there is very little displacement.

Complications.—The most serious complications arising from fracture of the clavicle are injuries of the brachial plexus and the subclavian vessels; the brachial plexus may be injured at the time of the accident by a displaced fragment, or may be involved in the callus during the repair of the fracture, causing paralysis of the arm. A displaced fragment of the clavicle has also produced injury of the internal jugular vein and the subclavian artery or vein.

Prognosis.—Fractures of the clavicle unite promptly, and examples of non-union in this fracture are extremely rare. Repair of this injury without deformity is also a very rare occurrence; there is usually some shortening with more or less angular deformity following cases of oblique

fracture of the clavicle, but, although the deformity may be marked, the functional result is generally very satisfactory.

Treatment.—In the treatment of fracture of the clavicle the principal indication is to carry the shoulder upward, outward, and backward—that is, to restore it to its normal position, and thus bring the acromial fragment, the one principally displaced, to its proper place. Although this may be easily accomplished by manipulation, great difficulty is experienced in keeping the shoulder in this position, for the unsupported weight of the shoulder tends to cause a reproduction of the deformity.

The movement of the scapula is an important factor in the production of deformity after fracture of the clavicle, and any dressing which does not secure fixation of this bone cannot fulfil the indications in treatment.

Treatment in the Recumbent Posture.—By this method of treatment excellent results may be obtained with the least amount of deformity, but the position is irksome, and many patients will not submit to it. The patient should be placed upon a firm mattress, and the head placed on a low pillow, with the chin slightly depressed, so as to relax the sterno-cleido-mastoid muscle and relieve the tension upon the sternal fragment of the clavicle. A folded towel should be placed in the axilla, to protect the surface of the arm and chest from excoriation, and the arm and forearm on the injured side should be flexed and placed across the chest, so that the fingers of the arm of the injured side will touch the opposite shoulder. In this position the inferior angle of the scapula moves forward and the superior angle backward, the weight of the body upon the lower angle keeping it in this position. The arm should be secured in place by broad strips of adhesive plaster or by a few turns of a roller bandage. It is remarkable in cases of fracture of the clavicle with great deformity how the parts assume their normal position if the patient is placed in the recumbent posture with the arm in the position just described. After the patient has remained two or three weeks at rest in this position, union is generally sufficiently firm to allow him to get out of bed and be about with the arm bound to the side and the forearm carried in a sling, or with a Velpeau bandage applied.

Treatment in the Erect Posture.—In treating a fracture of the clavicle in this posture the reduction of the deformity in the fractured bone is accomplished by carrying the shoulder upward, outward, and backward, but great difficulty is experienced with any form of dressing in keeping the shoulder from dropping and the scapula from rotating, producing recurrence of the deformity.

Temporary Dressing for Fracture of the Clavicle.—This may be accomplished by the application of a four-tailed bandage, made from a piece of muslin two yards in length and fourteen inches in width. A hole is cut in the centre, about four inches from its margin, to receive the point of the elbow; the bandage is then split into four tails in the line of the hole and to within six inches of it. The body of the bandage should be applied so that the point of the elbow rests in the hole, and, a folded towel being placed in the axilla, the lower tails should be carried, one anteriorly, the other posteriorly, diagonally across the chest and back to the neck on the side opposite the seat of fracture, and secured; the remaining tails are next

carried around the lower part of the chest and secured, so as to fix the arm to the side of the body. In the temporary dressing in fracture of the clavicle the same indications may be met by utilizing the clothing to secure the arm to the side and to form a sling, supporting the elbow from the opposite shoulder.

The Velpeau Dressing.—This dressing will be found a most satisfactory one in a large number of cases. The flexed arm carried across the chest draws the lower angle of the scapula forward by making tense the teres major muscle, and causes the acromial fragments of the clavicle to rise upward and backward. The position of the arm upon the chest also serves to keep the scapula outward. (Fig. 345.) In dressing a fracture of the clavicle in this position, the arm on the injured side should be flexed and brought across the front of the chest so that the hand will rest upon the shoulder of the sound side; a folded towel should be placed in the axilla and between the arm and side of the chest, to prevent excoriation of the skin surfaces. A *modified form* of the *Velpeau dressing* is applied as follows. A soft towel or a piece of lint should be placed in the axilla and allowed to extend over the side and front of the chest and held in position by a strip of adhesive plaster. The arm is next placed in the Velpeau position, and a good-sized pad of lint is applied over the scapula and held in place by a broad strip of adhesive plaster, two and a half inches in width and one and a half yards in length. This strip is continued downward and forward so as to pass over the point of the elbow, and is carried diagonally across the chest to the shoulder of the opposite side, and secured. A hole should be cut in it to receive the olecranon process. A compress of lint is placed over the seat of fracture and held in place by a strip of adhesive plaster; an additional strip of plaster is next carried over the spine, around the arm and chest, and secured on the opposite side of the chest. (Fig. 346.) Circular turns of a roller bandage are then passed around the chest, including the arm, from below upward, until the arm is securely fixed to the body, and the dressing is finished by making one or two turns of the third roller of Desault. (Fig. 347.) The time of removal of this dressing and its reapplication will depend upon the comfort of the patient and the manner in which the dressing keeps the parts in position. As a rule, in fractures of the clavicle the dressing should be removed at the end of the second or third day, the parts inspected, and the skin sponged off with dilute alcohol; the dressings are then reapplied, and if the patient is comfortable and the parts in good position the dressings should be made at less frequent intervals until union is completed. Union is generally quite firm at the end of four or five weeks,

Fig. 345.

Velpeau's dressing for fracture of the clavicle.

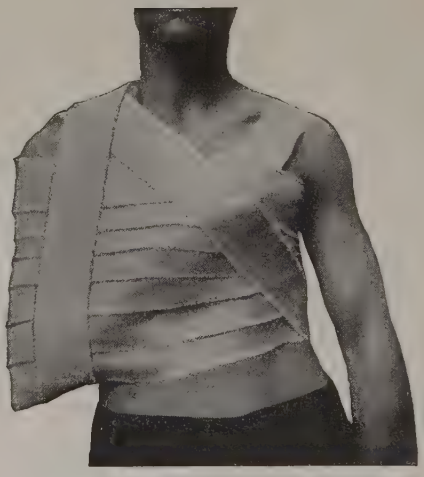
and at this time the dressings may be removed and the patient allowed to carry the arm in a sling for several weeks, but he should not undertake any work requiring forcible movements of the arm until eight or ten weeks have elapsed from the receipt of the injury.

Sayre's Dressing.—This dressing consists of two strips of adhesive plaster three and a half inches wide and two yards in length. The end of the first strip is made into a loop and secured by stitches, the loop is

Fig. 346.

Compresses and adhesive strips applied in dressing for fracture of the clavicle.

Fig. 347.



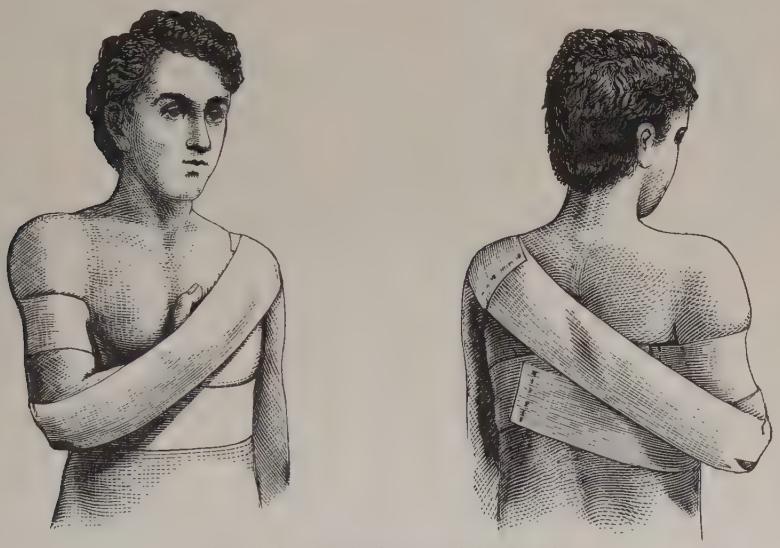
Modified Velpeau dressing for fracture of the clavicle.

passed around the arm just below the axillary margin, and the arm is then drawn downward and backward until the clavicular portion of the pectoralis major muscle is put sufficiently on the stretch to overcome the action of the sterno-cleido-mastoid muscle, and in this way draws the sternal fragment of the clavicle down to its place. The strip of plaster is then carried completely around the body and fastened or stitched to itself on the back. Before the elbow is secured by the second strip of plaster it should be pressed well forward and inward, and the forearm should rest across the anterior surface of the chest. The second strip is next applied, commencing upon the front of the shoulder of the sound side. From this point it is carried over the top of the shoulder diagonally across the back, under the elbow, and across the front of the chest to the point of starting, where it is secured. (Fig. 348.) A slit should be made in this strip to receive the projecting point of the olecranon process.

Fracture of the Clavicle in Children.—This fracture is very common in infants and children, and, as a rule, the deformity following is much less than that which is observed in adults. The fracture of the bone may be partial or complete, and the line of fracture transverse or oblique. In partial fractures where the deformity consists in bending of the bone, it may be

reduced by drawing the shoulders backward. If, however, the deformity is slight, it is better not to attempt to correct it, as by so doing an impacted or incomplete fracture may be converted into a complete one, and difficulty may subsequently be experienced in overcoming the deformity. In the treatment of fractures of the clavicle in children we usually apply the Velpeau or the modified Velpeau dressing, and, as these patients are particularly apt to disarrange their dressings, it is well to render it additionally secure by applying a few broad strips of adhesive plaster over the turns of the roller bandage, the strips following the turns of the bandage.

FIG. 348.



Sayre's dressing for fracture of the clavicle.

The most troublesome complication in the treatment of fractures of the clavicle in children is caused by excoriation of the skin where the surface of the arm comes in contact with the skin of the chest. This may be guarded against by using a dusting powder and by placing a fold of dry lint between the arm and the side of the chest. The time required for union in fractures of the clavicle in children is shorter than in adults, and the dressings may be removed at the end of three weeks.

FRACTURES OF THE SCAPULA.

Fracture of the scapula is a rare accident, and the infrequency of its occurrence may be explained by the fact that the bone is covered with large muscles and moves freely over the surface of the chest. Fractures of the scapula may involve the body or the angle of the bone, the neck, the acromion or the coronoid process, and the glenoid cavity.

Causes.—Fractures of this bone usually result from violence directly applied or by indirect force transmitted through the arm.

Fractures of the Body and Angles of the Scapula.—Fractures

involving this portion of the scapula are generally produced by great violence, and may be partial, complete, or comminuted. Fractures of the body of the bone are usually situated below the spine. (Fig. 349.)

Fig. 349.

Fracture of the body of the scapula. (Agnew.)

Symptoms.—If the body of the scapula or the inferior angle is broken, crepitus and mobility may be elicited by grasping the inferior angle with one hand while with the other hand the spine of the scapula is fixed. When the spine of the scapula is fractured, the line of fracture or displacement can be ascertained by passing the fingers along the spine of the bone. In incomplete fractures of the body of the bone it is impossible to make an accurate diagnosis; in complete fractures, however, there is usually more or less deformity.

Treatment.—After reducing the deformity by manipulation, a compress should be placed over the seat of fracture and held in position by broad strips of adhesive plaster; the arm should then be fixed against the side of the chest and held in position by a Velpeau's bandage or by the arm and chest bandage, and the arm should be immobilized, and the dressings, being changed at intervals, be retained for about four weeks.

Fracture of the Acromion Process.—This is also a rare fracture, and may be produced by direct violence applied from above or by the head of the humerus being driven forcibly upward against the acromion. (Fig. 350.)

Fig. 350.

Fracture of the acromion process. (Malgaigne.)

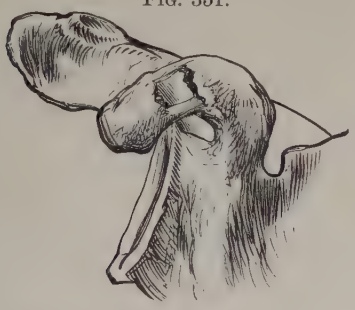
Symptoms.—The symptoms which point to fracture of the acromion process are flattening of the shoulder, disability of the arm, mobility, and crepitus. Crepitus may be obtained by placing the fingers over the acromion process and pushing the head of the humerus upward. This injury has been mistaken for dislocation of the head of the humerus; in the latter injury the acromion process stands out boldly, while in fracture the shoulder is flattened and the process is not prominent. In fracture of the acromion process the deformity may be reduced by pushing the head of the humerus upward, but the deformity recurs when the head of the humerus is allowed to drop downward. Union in this fracture is usually fibrous, but in spite of this very little permanent disability results.

Treatment.—In treating this fracture a folded towel should be placed between the arm and the chest; the arm should be placed vertically along the side of the chest, and the forearm should be flexed across the chest and secured firmly by the application of a Velpeau's bandage. This dressing should be retained for four weeks; the patient should then be allowed to carry the arm in a sling for several weeks longer.

Fracture of the Coracoid Process.—This fracture is extremely rare, and may be produced by direct violence or by violence transmitted through the displaced head of the humerus. (Fig. 351.)

Symptoms.—The signs of this injury are pain, mobility, and crepitus. If the finger be pressed firmly upon the coracoid process and the humerus be moved upward and downward, if fracture is present the fragment will be found to follow the movements of the arm, and not those of the scapula, in consequence of its connection with the coraco-brachialis and biceps muscles. Crepitus may be also felt during these manipulations. Union after fracture of the coracoid process is fibrous.

Fig. 351.



Fracture of the coracoid process of the scapula. (Neill.)

Fig. 352.

Fracture of the neck of the scapula. (Fergusson.)

Treatment.—This consists in applying a folded towel in the axilla and bringing the arm against the side of the body in the Velpeau position and securing it by turns of a Velpeau's bandage. This dressing should be retained for four or five weeks.

Fracture of the Neck and Glenoid Cavity of the Scapula.—Fracture of the neck of the scapula is an extremely rare injury. The fracture may extend to the glenoid cavity, or may separate the glenoid cavity and the coracoid process from the body of the scapula, or may simply separate the glenoid cavity from the scapula. (Fig. 352.)

Symptoms.—The most marked symptom in fracture of the neck of the scapula is the loss of the rotundity of the shoulder, with unusual prominence of the acromion process. This deformity results from the sinking downward of the head of the humerus and from the contraction of the coraco-brachialis and the short head of the biceps muscle. Crepitus may be obtained by pushing the head of the humerus upward.

Treatment.—In treating this fracture, a wedge-shaped pad five inches long and three inches wide should be placed in the axilla, and the arm should be fastened against the side of the body by the application of a Velpeau's bandage. At the end of four weeks the dressing should be permanently removed, and passive movements made to restore the function of the shoulder-joint.

FRACTURES OF THE HUMERUS.

Fractures of the humerus are very frequent injuries, constituting about eight per cent. of all fractures, and may involve the upper extremity, the shaft, or the lower extremity of the bone. Fractures of the upper extremity of the humerus include (1) fractures of the head and anatomical neck of the bone, (2) fractures through the tuberosities, (3) fractures of the surgical neck, and (4) fracture or disjunction of the upper epiphysis of the humerus.

Intracapsular Fractures of the Humerus.—These include fractures of the head or anatomical neck of the bone within the capsular ligament, and may be produced by force directly applied or by force transmitted through the arm. If an external wound exists, the nature of the injury may be determined by exploration with the finger or a probe. If, however, the fracture is not compound, the diagnosis is often obscure, but in some cases crepitus may be obtained. In comminuted fractures of the head of the humerus the fragments may become necrosed, and an abscess may form and the fragments subsequently be discharged, or, if this does not occur, the patient is apt to recover with more or less fixation of the shoulder-joint. The *treatment* of intracapsular fracture is similar to that employed in case of fracture of the anatomical neck, and will be described under the latter fracture.

Fracture of the Anatomical Neck of the Humerus.—This fracture, which is a very rare one, consists in a separation of the head of the bone from the tuberosities. The line of separation is usually in the slight constriction or groove which separates the head from the tuberosities, and therefore falls within the boundary of the insertion of the capsular ligament. (Fig. 353.) This fracture appears always to result from direct violence—that is, heavy falls or blows upon the shoulder. The separated head of the bone may remain loose within the capsule and be displaced forward or backward from the shaft, or may be impacted into the upper end of the shaft. Marked displacement of the separated head is often prevented, however, by the capsule and the tendons. The appearance presented after this fracture, if much fixation of the shoulder exists, is very similar to that after dislocation of the head of the humerus. The acromion becomes prominent from wasting of the deltoid muscle from disuse, but the humerus occupies a position in relation to the chest which is not possible in any form of dislocation of the head of the bone. Union in fractures of the anatomical neck of the bone may be unsatisfactory, and the head of the bone may become atrophied and remain ununited.

Fig. 353.

Fracture of the anatomical neck of the humerus. (Agnew.)

Symptoms.—The most marked signs of this fracture are pain in the joint after direct injury, loss of motion, and indistinct crepitus. If the shaft of the bone be drawn inward by the action of the pectoralis major and latissimus dorsi and teres major muscles, the upper end of the lower fragment may be felt, provided there is not too much swelling. In cases of

impacted fracture of the anatomical neck of the humerus, the shoulder becomes somewhat flattened, the acromion process less prominent, and the arm shortened.

Prognosis.—The surgeon should always give a guarded prognosis as regards the restoration of function in cases of fracture of the anatomical neck of the humerus. If the fracture passes entirely through the anatomical neck of the bone, separating the head from all connections with the lower fragment, union is not likely to take place. The separated head of the bone will lie loosely in the joint, and may become wasted as it is deprived of its blood-supply. When the separation is not complete and some fibres of the capsular ligament serve as a bond, union is possible, as also in cases of impacted fracture or in those which are partly within and partly without the capsule.

Treatment.—We consider the administration of an anæsthetic a very essential point before any dressing is applied for the treatment of this fracture, so that the surgeon may ascertain as far as possible the exact seat of fracture. While the patient is under the influence of the anæsthetic the surgeon should attempt, by manipulation, to reduce as far as possible any deformity. If the separated head of the bone is driven forward or backward, by making extension upon the arm and pressure upon the displaced head of the bone with the fingers it may be forced into its normal position. The dressing for this fracture is similar to that described for fracture of the surgical neck of the humerus, page 454.

Compound Fracture of the Anatomical Neck of the Humerus.—This constitutes a most grave injury, and one in which it is often advisable to enlarge the wound and remove the separated head of the bone. We are strongly of the opinion that the functional result is much more satisfactory where the head of the bone is removed, even though it may be possible for recovery to take place without such a procedure. Indeed, we believe that if all simple fractures of the anatomical neck of the humerus were treated by incision and removal of the separated head of the bone, the functional result would be much more satisfactory than is the case where more conservative methods of treatment are employed.

Complications.—One of the most serious complications occurring in fracture of the anatomical neck of the humerus is the displacement of the separated head through the rent in the capsular ligament. Various procedures have been recommended to return the displaced head of the bone to its normal position, such as manipulation, incision, and the introduction of a screw elevator into the displaced head of the bone to force it back to its normal position. If it cannot be replaced by manipulation, it should be freely exposed by incision and reduced or removed.

Fractures of the Tuberosities of the Humerus.—Fractures of the tuberosities of the humerus are rare injuries. Fracture of the greater tuberosity is occasionally seen as the result of force directly applied, or may occur in connection with the anterior dislocation of the head of the bone. The lesser tuberosity of the humerus is seldom fractured; the few cases that have been reported have occurred in connection with the upward dislocation of the head of the bone.

Symptoms.—When the greater tuberosity is separated it will be drawn backward by the action of the supraspinatus, infraspinatus, and teres minor muscles, while the shaft of the humerus will be carried inward by the subscapularis and forward by the pectoralis major muscle; the articulation will be increased in breadth, and, if the swelling is not too great, both the head of the bone and the tuberosity may be felt; there will be loss of voluntary outward rotation, and upon manipulation pain and crepitus. In this fracture union is fibrous.

Treatment.—The dressing employed in fracture of the greater tuberosity of the humerus is similar to that employed in fracture of the surgical neck of the humerus.

Fracture or Separation of the Upper Epiphysis of the Humerus.—This injury, which is quite rare, is seen in children, and is not likely to occur after twenty years of age, at which time bony union of the epiphysis has occurred. Separation of the upper epiphysis of the humerus does not necessarily open the shoulder-joint. It usually results from falls upon the shoulder, or from force transmitted through the arm, or from traction upon the arm. Epiphyseal separations are said to interfere with the subsequent growth of the bones.

Symptoms.—The prominent symptoms in this injury are pain, mobility, crepitus, and loss of function. There may be very little deformity if a portion of the periosteum remains untorn; in a large proportion of cases, however, a wedge-shaped prominence can be felt (Fig. 354) immediately

Fig. 354.

Deformity in separation of the upper epiphysis of the right humerus.

Fig. 355.

Skiagraph of separation of the upper epiphysis of the humerus. (By Professor Goodspeed.)

above the coracoid process of the scapula in front of the shoulder, which moves with motions of the shaft of the bone, and is the upper end of the lower fragment. The deltoid muscle is tense, and the head of the bone can be felt to occupy its normal position. The deformity in separation of the upper epiphysis of the humerus is shown in Fig. 355. To obtain crepitus it is necessary to make extension upon the arm and to push the shaft of the

humerus backward and then rotate it gently. The crepitus in this injury is softer and less distinct than that which is elicited in ordinary fractures.

Treatment.—As in all cases of fractures involving the region of the shoulder-joint, both for the purpose of accurate diagnosis and to render reduction of the deformity possible, we consider it essential that an anæsthetic should be given, and manipulation should be practised to push the anterior fragment or the shaft of the humerus back in contact with the head of the bone which rests in the glenoid cavity. In spite of the complete reduction of deformity at the time of the dressing, it is very usual to have the shaft of the bone drawn forward and upward by the action of the deltoid, pectoralis major and minor muscles, and a very characteristic deformity to result. The dressing for separation of the upper epiphysis of the humerus is similar to that for fractures of the surgical neck of the bone. The skiagraph (Fig. 356) shows the condition of the bone in the case of epiphyseal separation (Fig. 354) one year after the injury. In this case the restoration of function of the shoulder-joint was almost perfect.

Fig. 356.

Skiagraph of case shown in Fig. 354, one year after the injury. (By Professor Goodspeed.)

Fig. 357.

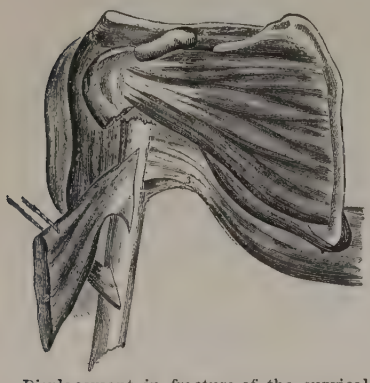
Fracture of the surgical neck of the humerus. (Agnew.)

Fracture of the Surgical Neck of the Humerus.—This fracture is one which occurs between the tuberosities and the insertion of the latissimus dorsi and teres major muscles (Fig. 357), and is usually produced by direct violence received when the arm is near the chest; the direction of the fracture may be transverse or oblique. It is a very common fracture in adults.

Symptoms.—The most marked signs of this fracture are loss of function in the arm, pain, shortening, which is most marked if the fracture is oblique, preternatural mobility, and crepitus; the latter symptom may be elicited by making traction upon the arm and rotating it. The lower fragment may be impacted in the upper fragment, in which case shortening would exist but crepitus could not be obtained.

Deformity.—The displacement in this fracture is largely confined to the lower fragment, which is drawn inward by the pectoralis major, latissimus dorsi, and teres major muscles. The upward displacement is produced by the action of the clavicular fibres of the pectoralis major and coraco-brachialis and the biceps and triceps muscles. (Fig. 358.)

Fig. 358.



Displacement in fracture of the surgical neck of the humerus, posterior view. (Agnew.)

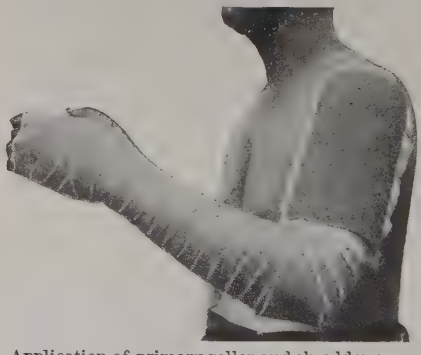
Prognosis.—The functional results following this fracture are usually very satisfactory: although some deformity may exist, examples of non-union are very rare.

Treatment.—After reducing the deformity by extension and manipulation, the treatment of this fracture, as well as of fracture of the anatomical neck or the greater tuberosity, and separation or disjunction of the upper epiphysis of the humerus, consists in the application of a primary roller from the fingers to the shoulder, and a well-padded felt or binders' board shoulder-cap (Fig. 359), extending from the acromion process to the lower third of the humerus and enveloping about one-half of the circumference of the arm (Fig. 360), which should be held in position by the turns of a roller bandage, and finished with spica turns of the shoulder. A folded towel should next be placed in the axilla and between the arm and the side of the chest; the arm should then be brought against the chest and secured in contact with it by circular

Fig. 359.

Shoulder-cap.

Fig. 360.



Application of primary roller and shoulder-cap.

turns of a bandage; the forearm should next be supported at the wrist in a sling from the neck, so that the weight of the arm and forearm may act as an extending force from the elbow. (Fig. 361.) This dressing should be renewed at intervals of two or three days, and should be retained for five or six weeks. After the third week gentle passive motion should be made at each dressing, to produce movement at the shoulder-joint.

Fracture of the Shaft of the Humerus.—This fracture may take place at any point between the surgical neck and the condyles of the bone.

The direction of fracture is generally oblique. In children, transverse and incomplete fractures may occur.

Causes.—This fracture usually results from direct violence, but numerous cases are recorded in which it was due to muscular action. *Spiral fractures* of the humerus occasionally occur, involving a large extent of the shaft, and are produced by forcible twisting of the bone.

Symptoms.—The most marked signs of this fracture are deformity, mobility, and crepitus. In fractures below the insertion of the deltoid, the upper fragment may be little changed in its position, as the deltoid on the one side and the pectoralis major and latissimus dorsi and teres major on the other antagonize one another; the lower fragment may be drawn upward and inward by the biceps and triceps muscles. In oblique fractures in the lower third of the bone, the lower fragment is likely to slip behind the upper one, and in this case the shortening is very marked, by reason of the contraction of the biceps and triceps muscles. (Fig. 362.)

Fig. 361.

Dressing for fractures of the upper portion of the humerus.

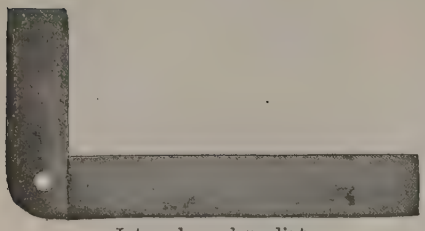
Fig. 362.

Fracture in the lower third of the humerus. (Agnew.)

Prognosis.—In simple fractures results are usually satisfactory; ununited fractures of the humerus, however, are not uncommon. In these cases the failure of union probably results from the interposition of muscular tissue or fascia between the ends of the bone or from imperfect immobilization of the fragments. Fractures of the shaft of the humerus are also sometimes complicated by paralysis from injury of the nerves of the arm at the time of the accident or from involvement of the nerves in the callus thrown out in the repair of the fracture. Gangrene has followed fracture of the shaft of the humerus from pressure of the fragment upon the brachial artery and vein. In many cases a certain amount of deformity or overlapping of the bones results in spite of the most careful treatment, but this does not in any way affect the subsequent strength and usefulness of the arm.

Treatment.—The treatment consists, first, in making extension and manipulation to reduce the deformity; a primary roller should then be applied to the arm from the tips of the fingers to the axilla; a well-padded internal angular splint (Fig. 363) applied to the inner surface of the arm, extending from the tips of the fingers to the axilla, and a well-padded shoulder-cap of binders' board or leather, extending from above the acromion to a point just above the condyles, should next be fitted upon the outer surface of the arm (Fig. 364), and secured by a bandage carried from the hand to the shoulder. (Fig. 365.) The arm should then be carried in a sling suspended from the neck. Another very satisfactory dressing for fracture of the shaft of the humerus consists in the application of a primary roller, as just described, and a short, well-padded splint, extending from the axilla to the inner condyle; three coaptation splints, extending from the shoulder to the elbow, are next applied to the anterior, outer, and posterior surfaces of the arm,

Fig. 363.



Internal angular splint.

Fig. 364.

Application of splint and shoulder-cap in dressing for fracture of the shaft of the humerus.

being held in position by a roller bandage. After the splints have been securely fixed, the arm should be bound to the side of the chest by circular turns of the bandage, and the forearm carried in a sling suspended from the neck. In the employment of either of these methods the dressings should be removed on the second day, the arm sponged with alcohol, and the splints reapplied in the same manner. The subsequent dressings should be made at intervals of two or three days, and the use of the splints continued for about six weeks. During the changing of dressings the patient will be saved much pain and the deformity will be lessened if an assistant keeps up extension of the arm from the elbow.

FRACTURES OF THE LOWER EXTREMITY OF THE HUMERUS.

No fractures which come under the care of the surgeon are accompanied by more anxiety as to the functional results than those involving the condyles of the humerus, for in many cases, in spite of the most judicious treatment, a certain amount of impairment of the motion of the elbow-joint or change in the relation of the forearm to the arm, producing a change in the carrying angle, or gunstock deformity, is apt to follow. (Fig. 366.) The

FIG. 365.

Dressing for fracture of the shaft of the humerus.

FIG. 366.

Deformity following fracture of the condyle of the left humerus.

unfavorable results in these cases cannot be attributed to a lack of care on the part of the surgeon, but are rather due to the character of the fracture itself. The displaced condyle may be in such a position that it is impossible to reduce it completely, and it may interfere with the flexion or extension of the arm, or disturb the relation of the bones of the forearm to the arm, or the callus thrown out in the repair of the fracture may prevent the motions of flexion and extension being satisfactorily accomplished. Fractures of the condyles of the humerus are more apt to involve the medical attendant in medico-legal difficulties than any other fractures. In all cases of fracture involving the lower extremity of the humerus, we consider it essential that the patient be placed under the influence of an anæsthetic and carefully examined, so that the surgeon may have the fullest opportunity to locate definitely the nature and extent of the fracture, to reduce the deformity, and to apply the dressing proper for the special variety of fracture.

Supracondyloid Fracture.—Supracondyloid fracture may consist in a fracture through the lower extremity of the humerus just above the limits of the expanded condyles, or in a separation of the lower epiphysis of the humerus. (Fig. 367.) The fracture just above the condyles may be oblique or transverse, but is usually more or less oblique, while the separation of the lower epiphysis is always transverse.

Causes.—Supracondyloid fractures result from force applied directly to the elbow or transmitted through the bones of the forearm.

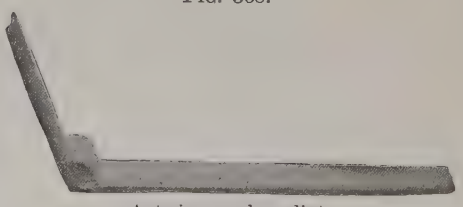
Fig. 367.

Separation of the lower epiphysis of the humerus.

Symptoms.—The most marked symptoms of this injury are shortening of the arm, crepitus, and deformity. Upon careful examination of the region of the elbow a projection will usually be discovered in front of the elbow, which is caused by the lower end of the upper fragment. A posterior prominence may also be felt, which is due to the upper end of the lower fragment. The deformity in this fracture so closely resembles a backward dislocation of the bones of the forearm at the elbow that a careful examination has to be made before the variety of injury can be determined. In cases of *supracondyloid fracture* there is shortening of the arm; the condyles of the humerus and the olecranon process are in the same line; the end of the upper fragment is above the bend of the elbow; the forearm is movable, and there will be crepitus; reduction is easily effected by extension and counter-extension, but the deformity reappears with the withdrawal of this force. In *dislocation* there is no shortening of the arm; the relation between the olecranon process and the condyles is changed, the olecranon being behind the condyles; there is no crepitus, and the broad end of the humerus may be felt below the bend of the elbow. There is also more or less rigidity at the elbow, and the deformity when once reduced does not tend to recur.

Treatment.—The treatment of this fracture consists, first, in making extension and counter-extension, and in using manipulation to bring the lower end of the bone into position. The forearm is next placed at an obtuse angle, or at an angle of less than ninety degrees, with the arm, and is covered by a primary roller from the fingers to the axilla. A well-padded anterior angular splint (Fig. 368) is next placed upon the anterior surface of the arm and forearm (Fig. 369), and is secured in position by ascending turns of a roller bandage. (Fig. 370.) For additional fixation a posterior rectangular gutter of binders' board or leather may be fitted to the posterior surface of the arm. The dressing should be removed at the end of twenty-four hours, as more or less swelling is apt to occur in the region of the elbow-joint, and the same dressing may be reapplied, and after this period may be changed at intervals of two or three days until four or five weeks have expired, at the end of which time the dressings may be permanently removed. After three weeks passive motion should be carefully made, the arm being fixed at the seat of fracture, while the forearm is flexed, extended, pronated, and supinated.

Fig. 368.



Anterior angular splint.

This fracture may also be dressed by fixing the arm in the position described above, and afterwards padding the region of the elbow-joint with cotton and

FIG. 369.

Primary roller and splint applied.

applying a plaster of Paris bandage extending from the fingers to the axilla. This dressing should be removed in two weeks, and a fresh bandage applied, to be worn for two or three weeks longer.

Condyloid Fractures of the Humerus.—Fractures involving the condyles of the humerus may separate either the external or the internal

FIG. 370.

Dressing for fractures of the lower end of the humerus.

condyle, or a transverse fracture may occur through the condyles while a vertical fracture separates them from each other; this is known as a T-fracture.

Fractures of the condyles of the humerus may involve the epicondyle, in which case the articulation is not implicated, or may involve the external or internal condyles and communicate with the elbow-joint. Fractures of the condyles are very common in children, but rather infrequent in adults.

Causes.—These fractures result from falls or blows in which the force is applied to the side or to the point of the elbow or is transmitted through the bones of the forearm.

Prognosis.—In all fractures involving the condyles there is apt to be more or less stiffness or loss of motion at the elbow-joint, either from dis-

placement of the fragments or from the peculiar disposition of the callus resulting from the repair of the fracture.

T-Fracture of the Condyles of the Humerus.—This fracture consists in a transverse separation of the humerus through the condyles, with a vertical fracture extending into the articulation. (Fig. 371.)

Causes.—T-fracture results from force applied to the back of the elbow while the arm is flexed, driving the olecranon forward against the condyles.

FIG. 371.

T-fracture of the condyles of the humerus.

FIG. 372.

Fracture of the internal condyle of the humerus. (Agnew.)

Symptoms.—The most marked symptoms of this fracture are increased breadth of the elbow in consequence of the separation of the condyles, crepitus elicited when the condyles are moved either backward or forward or when they are forced together, and mobility when the condyles are pressed in opposite directions.

Fracture of the Internal Condyle of the Humerus.—Here the line of fracture is oblique to the longitudinal axis of the bone, and usually involves the joint to a greater or lesser extent. (Fig. 372.)

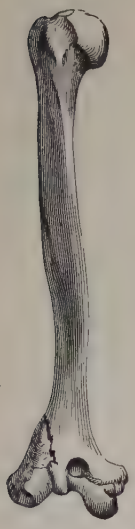
Symptoms.—These are pain and rapid swelling, and upon extension the forearm is inclined inward, causing the deformity which is known as "gunstock deformity," resulting from the internal condyle being displaced upward. By grasping the internal condyle between the thumb and the fingers crepitus may be elicited, and preternatural mobility may be felt if the humerus and the forearm are moved laterally.

Fracture of the External Condyle of the Humerus.—In this fracture the line of separation is usually oblique, and includes the articular surface of the humerus. (Fig. 373.)

Symptoms.—The symptoms of this fracture are pain, swelling, deformity, crepitus, and mobility. When the arm is extended it inclines to the ulnar side. Deformity in this fracture results from downward displacement of the external condyle.

Fracture of the condyles of the humerus is often confounded with dislocation at the elbow, but if the surgeon bears in mind the facts that in dislocation the epicondyloid eminences are in line, whereas in fracture one is higher or lower than the other, that crepitus can be obtained in fracture and is not present in dislocation, and that the forearm is flexed upon the arm in posterior dislocation, whereas it may be extended in fracture of the condyles, little difficulty in diagnosis will be experienced.

Fig. 373.



Fracture of the external condyle of the humerus. (Agnew.)

Prognosis.—In fracture of either the external or the internal condyle a guarded prognosis should always be given, for, in spite of the most careful treatment, more or less stiffness and restriction of the motions of the elbow-joint, with deformity, may result.

Fig. 374.

Fracture of the internal epicondyle of the humerus. (Agnew.)

Fracture of the Internal Epicondyle.—In children, separation of the internal epicondyle, which is an epiphysis, is not an uncommon accident, and may result from force directly applied or from muscular action. (Fig. 374.)

Symptoms.—The most marked symptoms of fracture of the epicondyle are pain, swelling, mobility, and crepitus. The displacement, as a rule, is a little downward and forward, due to the action of the pronator and flexor muscles. The ulnar nerve, from its close relation to this prominence, is occasionally injured in this fracture, which is shown by disordered sensibility in the parts to which it is distributed. This fracture is not so liable to be followed by stiffness of the articulation as are fractures involving either the external or the internal condyle.

Treatment of Fractures of the Lower Extremity of the Humerus.—Some diversity of opinion exists among surgeons as to the advisability of treating these fractures in the extended or in the flexed position. There is no doubt that the deformity can best be reduced and the reduction maintained by keeping the arm in the extended position, and that the "carrying function" of the arm is best preserved by this position, as has been pointed out by Allis. On the other hand, if stiffness or ankylosis of the elbow results, an arm which is flexed is much more useful to the patient than one which is fixed in the extended position. In view of these facts, we are inclined, as a rule, to treat the arm in the flexed position, unless it is found that it is impossible to reduce the deformity, in which case we consider it good practice to treat the arm in the extended position for two weeks, until the fragments have attained some fixation, and then to administer an anæsthetic and flex the arm to a right angle, applying a splint to keep it in this position. The dressing of condyloid fractures consists in applying first a primary roller from the tips of the fingers to the axilla, and then either an anterior straight splint or an anterior angular splint, securing

the splint in position by the turns of a roller bandage. (Fig. 370.) These fractures may also be treated by reducing the deformity, and, after applying a roller and cotton padding to the elbow, fixing the arm in the extended or in the flexed position by a plaster of Paris bandage. In children, at the end of three weeks the union is usually sufficiently firm to allow the splints to be permanently removed, and at this time passive motion should be made by grasping the condyles of the humerus with one hand and flexing, extending, supinating, and pronating the forearm with the other. In many of these cases, for some months after removal of the splints marked impairment of motion is present, which seems largely to be due to the deposition of callus either upon the anterior or the posterior surface of the condyles, interfering with the motions of extension and flexion of the forearm. If a case which presents very marked disability shortly after fracture be examined some months later, it is surprising to find how the motion of the elbow has returned as the callus has been absorbed.

A method of treating fractures of the condyles of the humerus which has recently attracted some attention both in this country and abroad consists in reducing the deformity under an anæsthetic and then placing the elbow in a position of acute flexion, maintaining this position by securing the arm and forearm together by broad straps of adhesive plaster applied as a double figure-of-eight; the arm is then supported in a sling from the neck or is secured to the body by the turns of a bandage. This dressing is applied for three or four weeks, and is then removed and the arm gradually extended. It is held that by this method of dressing better motion is obtained and the tendency to gunstock deformity is lessened.

Compound Fractures of the Humerus.—Compound fractures of the humerus may involve any portion of the bone. In compound fractures of the head of the humerus, primary excision of the head of the bone offers the patient the best functional result. In compound fractures of the shaft of the humerus, after thoroughly sterilizing the wound, the treatment consists in securing primary fixation of the fragments by means of heavy silver wire or kangaroo tendon sutures, or by silver splints fixed to the fragments by means of screws, or by bone ferrules. The subsequent treatment consists in the use of drainage, closure of the wound, the application of an antiseptic gauze dressing, and the use of fixation dressings similar to those employed in cases of simple fractures of the humerus.

In compound fractures involving the *condyles of the humerus* and the *elbow-joint* it is a question whether it is wise to attempt to obtain primary fixation of the fragments, as in spite of the greatest care in the treatment a certain amount of loss of function results. It is better in these cases to resort to partial excision of the elbow-joint—that is, the removal of fragments and excision of the end of the humerus—to give a good surface for articulation with the bones of the forearm, then to drain the wound, apply an antiseptic gauze dressing and splint for a few weeks, fixing the arm in the flexed or partly extended position, and after this time to encourage motion at the elbow to obtain a movable joint.

FRACTURES OF THE BONES OF THE FOREARM.

Fractures of the bones of the forearm are injuries of frequent occurrence. Both bones may be broken at the same time, or either may be broken separately. The radius, from its direct articulation with the bones of the carpus, is much more frequently the seat of fracture than the ulna. These fractures occur at all periods of life, and are very frequently seen in children. Fractures of the bones of the forearm may result from blows directly on the forearm, or from falls in which the force is transmitted from the hand.

Fig. 375.

Fracture of both bones of the forearm.

Fractures of the Radius and Ulna.—These fractures may take place at any portion of the bones, but are most frequently met with below the middle of the forearm.

Causes.—They are produced by direct or indirect force, and result from falls upon the hand or from the passage of heavy bodies across the forearm. When fracture of both bones of the forearm results from direct force, the bones are apt to be broken upon the same level. (Figs. 375 and 377.) When, however, the fracture occurs from indirect force, the radius is apt to give way at a higher level than the ulna.

Symptoms.—The most marked signs in these fractures are deformity (Fig. 376), which may be lateral, anterior, or posterior, preternatural mobility, crepitus, and loss of function. Great deformity in fracture of both bones of the forearm is seen in children, in whom the fractures are often incomplete, and constitute what are known as "greenstick" fractures.

Prognosis.—As a rule, the results following fractures of both bones of the forearm are good where the deformity has been satisfactorily reduced and the parts have been immobilized by proper dressing. Where the immobilization of the fragments is insufficient or the displacement is not corrected, contact of the bones or fusion of the callus may interfere with the

Fig. 376.

Deformity in fracture of both bones of the forearm.

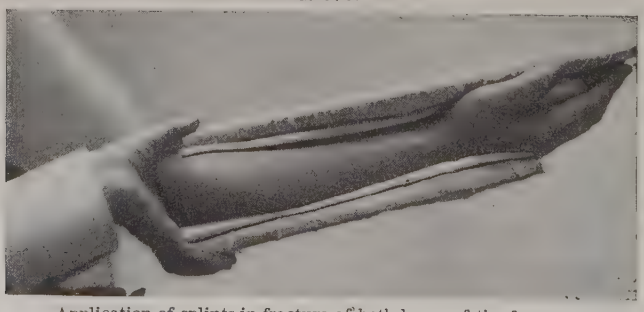
Fig. 377.

Skiagraph of fracture of both bones of the forearm. (Dr. J. M. Stern.)

motions of pronation and supination of the forearm. Non-union is not uncommon in fractures of the bones of the forearm.

Treatment.—In the treatment of fractures of both bones of the forearm the forearm should be flexed, to relax the muscles which arise from the humerus, and extension and counter-extension should be made; at the same time the fragments should be pressed into their proper position. Considerable diversity of opinion exists among surgeons as to the position in which the forearm should be placed in the treatment of these fractures. Some surgeons prefer the position between pronation and supination, while others prefer the supine position. Our experience has led us to think that the best results are obtained by treating fractures of the forearm in the supine position, as advocated by Lonsdale, where the radius is broken above the insertion of the pronator radii teres, for the reason that the biceps muscle, inserted into the tuberosity of the radius, acts as a supinator of the forearm. If the upper fragment of the radius is supinated by the action of the biceps, and the forearm is placed in the position between pronation and supination, the lower fragment of the radius in half supination will then be united to the upper fragment in full supination, and axial deformity will result, the patient being unable to supinate the arm fully, thus losing the advantage of full rotation; whereas if the lower fragment is supinated to correspond with the supination of the upper fragment the line of the radius will be complete. We therefore treat these fractures by reducing the deformity by counter-extension and manipulation, and apply a well-padded flat straight splint to the anterior surface of the forearm, extending from the bend of the elbow to a little beyond the tips of the fingers. A well-padded splint is next applied to the posterior surface of the arm, from the tip of the olecranon to a point just below the wrist. (Fig. 378.) The splints are held in

Fig. 378.



Application of splints in fracture of both bones of the forearm.

position by the application of a roller bandage (Fig. 379), and the forearm should be supported in a broad sling. Care should be taken that the anterior splint, if it be applied while the arm is extended, does not press against the brachial artery at the bend of the elbow when the arm is flexed. This fracture may also be dressed by applying a long straight splint to the posterior surface of the arm, extending from the elbow to the tips of the fingers, and a short anterior splint extending from the elbow to the wrist, both being held in place by a bandage. A plaster of Paris bandage may be

employed to secure the splints, and a few turns of the bandage may be carried around and above the elbow to prevent rotation of the forearm. No primary roller should ever be applied in cases of fracture of the bones of the forearm. The use of a primary roller in these cases, with the pressure of the anterior splint against the brachial artery, possibly accounts for the cases of gangrene of the forearm which have occasionally followed these fractures. Care should be taken that the splints are a little wider than the

FIG. 379.

Dressing for fracture of both bones of the forearm.

arm, for if narrow splints be used the lateral pressure of the bandage may tend to force the bones together and thus diminish the interosseous space, and as a result union by callus between the bones may occur and prevent the motions of pronation and supination. The subsequent dressings are made every second or third day, and at the end of four weeks union is usually sufficiently firm to permit of the permanent removal of the splints. After three weeks passive motion should be made, pronation and supination of the forearm and flexion and extension of the wrist being practised at each dressing.

Incomplete or Greenstick Fractures of the Bones of the Forearm.—These fractures are seen in infants and children, and are often accompanied by marked deformity; one bone may be completely broken, while the other is partially broken or bent, or both bones may present incomplete fracture.

Treatment.—In the treatment of greenstick fractures of the forearm, the most important point is to reduce the deformity; this is accomplished by making pressure upon the bones, and in reducing the deformity the incomplete fracture is generally converted into a complete one. The dressing consists in the application of splints, as in cases of fractures of both bones of the forearm.

FRACTURES OF THE RADIUS.

Fractures of the radius may occur at any point in its length, but the most common seat is at the lower extremity.

Fracture of the Neck of the Radius.—This is a very rare injury. The most prominent sign of this injury is failure of the head of the radius to rotate with the movements of the shaft, and in making these movements, if a fracture exists, crepitus can usually be detected.

Treatment.—In the treatment of this fracture the forearm should be flexed, to relax the biceps muscle, and a well-padded anterior angular splint should be applied to the forearm and arm, and held in position by a roller bandage. The dressing should be changed at intervals, and the splint should be removed at the end of four weeks. The plaster of Paris bandage may also

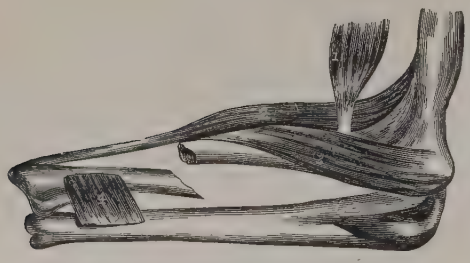
be employed in the treatment of this fracture. Passive motion should then be practised, to regain the motions of pronation and supination of the forearm.

Fracture of the Head of the Radius.—This fracture is an extremely rare one, and may be associated with a fracture of the neck of the radius or with fracture of the coronoid process of the ulna. Its existence as an independent injury has been questioned by many surgeons. The diagnosis of this injury from fracture of the neck of the radius would be extremely difficult. The treatment of the injury is similar to that employed in fracture of the neck of the bone.

Fracture of the Shaft of the Radius.—This fracture usually results from direct violence, but may follow a fall upon the hand.

Symptoms.—In this injury there is noticed a loss of both pronation and supination; the upper end of the radius when the hand is rotated remains fixed; pain, crepitus, and preternatural mobility may also be present. The displacement consists in tilting forward of the upper fragment by the action of the biceps muscle, and rotation inward by the action of the pronator teres; the lower fragment is drawn towards the ulna by the action of the pronator quadratus and the supinator radii longus. (Figs. 380 and 381.)

Fig. 380.



Deformity in fracture of the shaft of the radius. (Agnew.)

Prognosis.—The results following this fracture are usually very satisfactory, unless the lower fragment is drawn so close to the ulna that the callus forms an attachment to the ulna and interferes with the motions of pronation and supination.

Treatment.—The arm should be flexed, to relax the biceps, and the hand adducted, and the forearm should be placed in the supine position. Well-padded anterior and posterior straight splints should be applied and held in position by a roller bandage.

Fig. 381.

Skiagraph of fracture of the shaft of the radius. (Leonard.)

Fractures of the Lower End of the Radius.—Fractures of the lower end of the radius are frequent injuries.

Causes.—They may be produced by direct force, yet in the great majority of cases they are caused by violence transmitted through the carpus by falls upon the palm of the hand. If the weight of the body is received upon the metacarpo-phalangeal portions of the hand, the resistance offered by the antero-radio-carpal ligament to extreme extension causes a transverse frac-

ture of the lower end of the bone. There is often a dislocation or fracture of the styloid process of the ulna associated with fracture of the lower end of the radius. The most common fracture of the lower end of the radius is known as Colles's fracture; it occupies a position from half an inch to an inch and a half above the articular surface of the bone, and presents a very characteristic deformity, known as the silver fork deformity. (Fig. 382.) The fracture may consist in an oblique or a transverse separation of the bone above the articular extremity; it may be comminuted (Fig. 383), or it may consist in a separation of the posterior lip of the articular surface of the radius; the latter is extremely rare, and is known as Barton's fracture.

Fig. 382.

Deformity in Colles's fracture.

Fig. 383.

Comminuted fracture of the lower end of the radius. (Agnew.)

Symptoms.—The symptoms of fracture of the lower end of the radius are pain, disability, and crepitus. There is also usually a prominence on the back of the arm, due to the upper end of the lower fragment, and another in front of the arm, due to the lower end of the upper fragment. There is a certain amount of inclination of the hand to the radial side of the arm, accompanied by prominence of the styloid process of the ulna.

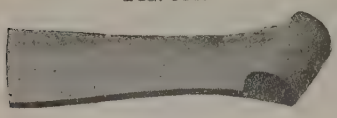
Diagnosis.—Fracture of the lower end of the radius may be confounded with dislocation at the wrist; this is an extremely rare accident, while fracture is a very common one. In dislocation there is no crepitus, but in fracture this can usually be recognized, except in cases of impacted fracture. The deformity in fracture is reduced by extension and counter-extension, and when the force is removed the deformity reappears. In dislocation when the deformity is once reduced there is no tendency to its reproduction.

Prognosis.—The results following fracture of the lower end of the radius are generally satisfactory if the primary deformity is corrected, but occasionally a certain amount of impairment of motion of the wrist is observed, and sometimes interference with pronation and supination results in spite of the most careful treatment.

Treatment.—The treatment of fracture of the lower end of the radius consists, first, in reducing the deformity. This is accomplished by grasping the forearm above the seat of fracture and with the other hand grasping the hand of the fractured arm and making extension, at the same time tilting the lower fragment backward by bending the hand back; then by suddenly flexing the hand the lower fragment is brought downward and forward and the deformity is corrected. We are satisfied that many of the unsatisfactory results following fractures of the lower end of the radius

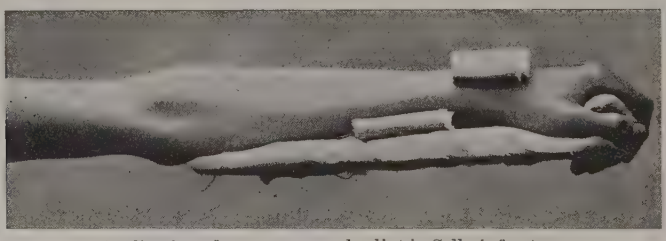
are due to an imperfect reduction of the fragments at the time of the first dressing, and with this fact in view we think it is advisable to anæsthetize the patient and use considerable force if necessary to place the fragment in its proper position. The forearm should next be placed upon a well-padded Bond splint (Fig. 384), which consists of a splint with a block of wood set obliquely upon it, upon which the hand rests, causing its adduction. In addition to this splint two folded compresses of lint are applied, one over the lower end of the upper fragment and the other over the upper end of the lower fragment. (Fig. 385.) The arm should be fixed in the supine position, or in the position between supination and pronation, and the splint and compresses held in place by the turns of a roller bandage. (Fig. 386.) The

Fig. 384.



Bond splint.

Fig. 385.

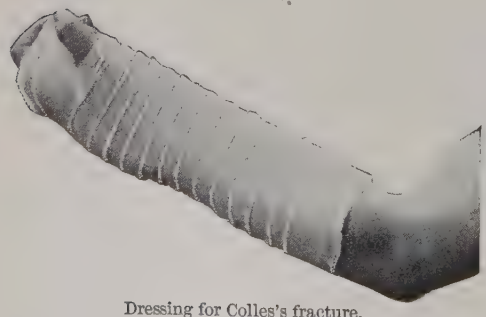


Application of compresses and splint in Colles's fracture.

after-treatment of this fracture consists in the renewal of the dressings after twenty-four hours, and after this the dressings can be changed at intervals of two or three days, and at the end of four weeks the splint should be removed and the patient encouraged to use the arm. The Bond splint allows the patient to move the fingers during the course of the treatment without interfering with the fixation of the fragments.

Another method of treating Colles's fracture after the reduction of the deformity consists in placing upon the dorsal surface of the forearm a padded straight splint, extending from the elbow to the tips of the fingers, and a short straight splint upon the palmar surface of the arm, extending from the elbow to the wrist. These splints are held in position by a bandage, and the forearm carried in a sling with the hand inclined to the ulnar side. The hand should be bandaged to the posterior splint for about seven days and then set free. The posterior splint should be left long for another week ; at the end of this time it should be shortened so as to extend only to the wrist-joint, and the patient should be encouraged to

Fig. 386.



Dressing for Colles's fracture.

use the fingers and make motions of the wrist. At the end of three weeks both splints should be removed, and the patient should carry the forearm in a sling for a few weeks longer and be encouraged to use the hand.

As stiffness of the wrist and the fingers is very apt to follow this fracture, it is important that the fingers should be moved when the dressings are changed, the wrist gently flexed and extended, and, while the fragments are fixed with one hand, the motions of pronation and supination practised.

Ununited fractures of the lower end of the radius are extremely rare: we know of no reported case of non-union in Colles's fracture.

Fracture or Separation of the Lower Epiphysis of the Radius.—This accident presents more or less the deformity of the ordinary Colles's fracture, and is quite common in children.

Fig. 387.

Separation of the lower epiphysis of the radius.

Symptoms.—The deformity in separation of the epiphysis consists in a marked angular projection on the palmar surface of the forearm above the wrist, and a corresponding depression upon the dorsal surface. (Fig. 387.) Crepitus can be obtained upon making extension and counter-extension and manipulation, but it is usually softer in character than that occurring in fractures of the lower end of the radius.

Treatment.—By making extension and counter-extension and manipulation the deformity can be reduced, and when once reduced the tendency to its reproduction is not so marked as in the case of Colles's fracture. The treatment consists in placing the forearm in the supine position and applying a straight padded splint to the anterior surface of the forearm, and a padded splint to the posterior surface of the forearm; or an ordinary Bond splint with compresses may be applied. The splints are held in position by a roller bandage, and the subsequent management of the case is similar to that of cases of fracture of the lower end of the radius. The results following epiphyseal separation of the lower end of the radius are usually very satisfactory.

FRACTURES OF THE ULNA.

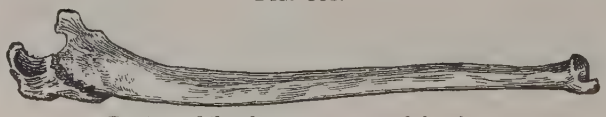
Fracture of the Shaft of the Ulna.—This fracture is usually produced by direct force from blows or from falls upon the ulnar side of the forearm. Displacement in fracture of the shaft of the ulna may be in any direction, often being determined by the direction of the force which produced the fracture. Fractures of the ulna may be oblique or transverse, and if the radius is not broken there will be no overlapping.

Prognosis.—In fractures of the shaft of the ulna, union generally takes place without marked deformity. Non-union is much more common in the ulna than in the radius. We have seen a number of cases of ununited fracture of the ulna in which non-union seemed to be due to the fact that the fractures were treated with a short single anterior splint which did not control the movement of the fingers.

Treatment.—In the treatment of fractures of the shaft of the ulna, any displacement which exists should be reduced by manipulation with the fingers, and care should be taken, if the fragments are displaced towards the radius, to bring them into their natural position, so as to prevent subsequent loss of pronation and supination. After reducing the deformity the hand and forearm should be placed in the supine position, and a well-padded splint applied to the anterior surface of the forearm from the bend of the elbow to the tip of the fingers; a shorter padded splint, extending from the olecranon to the wrist or a little beyond, should be placed upon the posterior surface of the forearm, and the two splints should be held in position by the turns of a roller bandage. (Fig. 379.) Some surgeons prefer to treat fractures of the shaft of the ulna with the forearm in the position between pronation and supination. The dressings should be changed at intervals of two or three days, and at the end of four or five weeks the splints may be permanently removed. A plaster of Paris dressing from the knuckles to the elbow may also be employed.

Fracture of the Olecranon Process of the Ulna.—This fracture is seldom seen in children, but is not infrequent in adults. The line of fracture may separate the tip, or pass through the base or the middle of the olecranon process. (Fig. 388.)

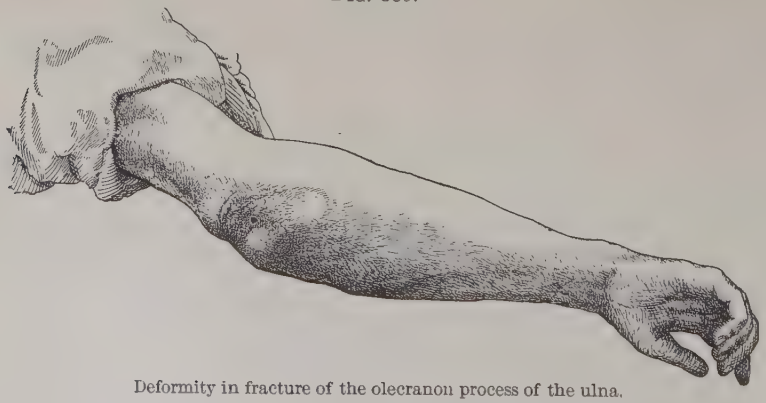
Fig. 388.



Fracture of the olecranon process of the ulna.

Symptoms.—The symptoms of fracture of the olecranon process are pain at the back of the elbow, complete loss of power of extending the forearm, and a prominence above the normal position of the olecranon process (Fig. 389), the fragment being drawn up by the action of the triceps muscle.

Fig. 389.



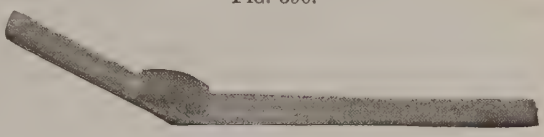
Deformity in fracture of the olecranon process of the ulna.

Crepitus may also be felt, and lateral motion of the fragment can be obtained by manipulation with the fingers. Upon flexion of the arm a marked gap, into which the fingers can be pressed, will be seen behind the joint.

Prognosis.—In fractures of the olecranon process fibrous union usually is obtained. Fibrous union in these cases probably results from the difficulty in bringing about perfect apposition of the fragments and from the presence of synovial fluid in the fissure between them. We had recently under our care an oblique fracture of the upper portion of the ulna which separated the olecranon process, and in this case non-union resulted. Upon exposing the parts by incision the synovial fluid escaped from the fissure in the bone, and the surfaces were lined with a smooth membrane resembling synovial membrane. In this case firm bony union was obtained by freshening the surfaces and introducing heavy wire sutures.

Treatment.—In the treatment of this fracture the arm should be extended and a primary roller applied from the tips of the fingers to a point just below the elbow. A well-padded straight or obtuse-angled splint (Fig. 390), extending from the shoulder to the tips of the fingers, should be applied upon the anterior surface of the arm and forearm; a compress of lint should next be placed just above the upper fragment and held in place by one or two strips of adhesive plaster, applied obliquely (Fig. 391) from above downward, and fastened to the splint, and the splint should be secured by a bandage. (Fig. 392.) This dressing should be changed at intervals of two or three days, and the splint should not be permanently discarded until about six weeks after the injury. This fracture may also be treated by means of a plaster of Paris bandage. Passive motion should not be practised until two or three weeks have elapsed.

Fig. 390.



Obtuse-angled splint.

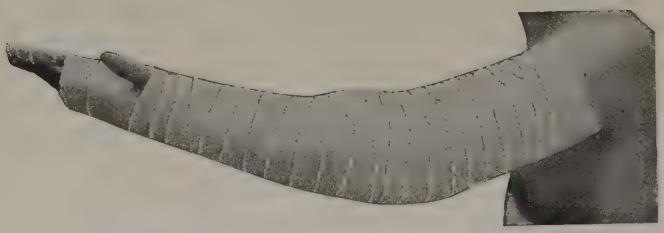
Fig. 391.

Application of splint and compress in fracture of the olecranon process.

In making passive motion the fragments should be held firmly with the fingers while pronation and supination of the forearm and slight extension and flexion are practised. As the union in this fracture is usually fibrous, it is important that as close apposition as possible of the fragments be obtained, as a long fibrous union interferes very markedly with extension of the forearm. In spite of fibrous union in cases of fractures of the

olecranon, although there may be a certain amount of disability immediately following the repair of the fracture, in a short time the function of the arm is usually satisfactorily regained.

Fig. 392.



Dressing for fracture of the olecranon process of the ulna.

Fracture of the Coronoid Process of the Ulna.—This fracture is an extremely rare one. In one hundred and thirty cases of fracture of the ulna admitted to the Pennsylvania Hospital three fractures of the coronoid process were recorded. We have seen recently a case in which this fracture unquestionably existed. (Fig. 393.) It is produced by falls upon

Fig. 393.

Fracture of the coronoid process of the ulna.

the hand, which drive the process against the articular surface of the humerus, or may result from posterior dislocation of the elbow, or from violent muscular action.

Symptoms.—The most marked symptoms in this fracture are a posterior displacement of the bones of the forearm, and prominence of the detached process in front of the elbow. This displacement may be reduced by extension, but upon relaxing the extending force the bones will tend to slip backward.

Treatment.—Fracture of the coronoid process should be treated by first flexing the arm to a right angle and applying a primary roller from the tip of the fingers to the shoulder. A well-padded anterior angular splint should next be applied to the anterior surface of the arm and forearm. This dressing should be changed at intervals of two or three days, and gentle passive movements of the elbow made after two weeks. The splint should be permanently removed at the end of three weeks.

Fracture of the Styloid Process of the Ulna.—Fracture of this process may result from direct force or may be associated with fractures of the lower end of the radius, and is probably due in the latter case to extreme tension upon the internal lateral ligament.

Symptoms.—The usual signs of fracture of the styloid process of the ulna are pain, swelling, and deformity at the inner part of the wrist; when the hand is abducted the process may be seen and felt to leave the lower end of the bone, and crepitus may be obtained.

Treatment.—In the treatment of this fracture a Bond splint may be employed, which carries the hand to the ulnar side of the arm and relaxes the internal lateral ligament, and thus favors the restoration of the process to its normal position. After applying the splint, a compress should be applied over the process, and the splint and compress should be held in position by a roller bandage.

Fracture of the Carpal Bones.—The carpal bones, from their shape, being short and irregular and compactly bound together by powerful ligaments, do not often present examples of simple fracture. Fractures in these bones are readily overlooked.

Compound Fractures of the Carpal Bones.—These fractures are of more frequent occurrence, and result from gunshot injuries and from crushing forces applied to the hand or the wrist, and are frequently seen in machinery and railway accidents.

Treatment.—The treatment of compound fracture of the carpal bones consists in sterilizing the wound, in removing foreign bodies and loose fragments of bone, and if it is found that the bones are not hopelessly crushed, and the parts above and below are not seriously injured, the wound should be dressed with an antiseptic dressing and the arm and hand fixed upon a palmar splint. In many cases of compound fracture of the carpal bones, however, the metacarpal bones and phalanges of the fingers and the tissues of the hand are so extensively involved in the injury that amputation is required.

Fractures of the Metacarpal Bones.—Fractures of the metacarpal bones are not common. The metacarpal bones most frequently broken are those of the index, ring, and little fingers.

Causes.—These fractures may result from crushing force which does extensive damage to the soft parts and breaks several bones at the same time. The bones are also sometimes broken by force transmitted from the knuckles when blows are struck with the clinched fist. These fractures are rarely seen in children. The usual displacement is projection of the proximal fragment upon the dorsum of the hand.

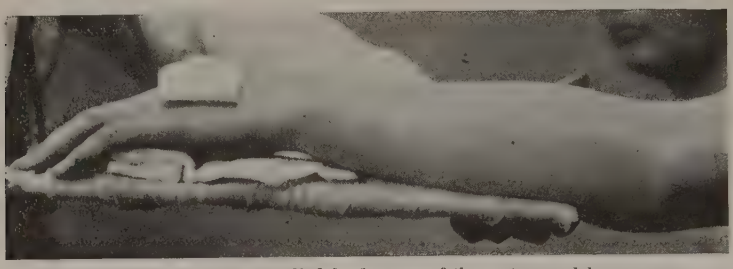
Symptoms.—The symptoms in fracture of the metacarpal bones are pain, preternatural mobility, and crepitus, with a prominence on the back of the hand. It is often difficult to elicit mobility and crepitus in these fractures. Crepitus may be obtained by placing one finger upon the knuckle and another over the supposed seat of fracture, and manipulating the parts.

Treatment.—In the treatment of fracture of the metacarpal bones, after reducing the deformity by pressure, a pad should be placed under the palm of the hand, and a well-padded straight splint applied to the palmar surface of the hand and forearm (Fig. 394), extending from the tips of the fingers half-way up the forearm. A compress of lint should be applied over the seat of fracture, and the splint and compress held in position by the turns of a roller bandage. (Fig. 395.)

Compound Fractures of the Metacarpal Bones.—In many cases of compound fractures of the metacarpal bones the injury to the tissues of the hand is so extensive that amputation of the hand may be required, although with the modern methods of wound treatment conservative treat-

ment should always be attempted. By thorough sterilization of the parts and the removal of detached fragments it is possible for recovery to occur, with a more or less useful hand, even where there have been extensive comminution and destruction of the metacarpal bones.

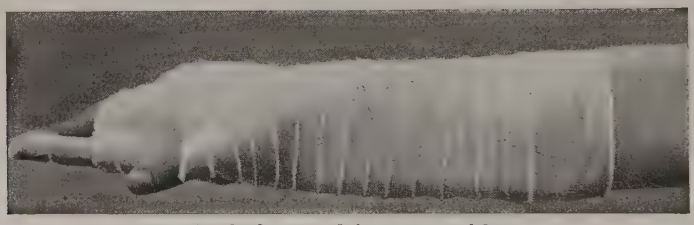
Fig. 394.



Splint and compress applied for fracture of the metacarpal bones.

Fractures of the Phalanges of the Fingers.—Fractures of the phalanges of the fingers may involve the phalanges of a single finger or of several fingers.

Fig. 395.

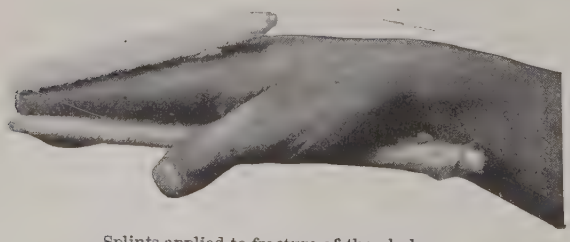


Dressing for fracture of the metacarpal bones.

Symptoms.—The symptoms of this fracture are preternatural mobility and crepitus. As a rule, the deformity is not very marked and is easily reduced.

Treatment.—In the treatment of fractures of the phalanges, after reducing the deformity by manipulation, a narrow padded splint is applied to the palmar surface of the hand and of the injured finger; a posterior short splint, extending from the knuckle to the tip of the finger, may also be applied, the splints being held in position by the turns of a narrow roller bandage. (Fig. 396.) If there is lateral displacement, short lateral splints may also be employed in conjunction with the palmar and dorsal splints. A very satisfactory method of treating these fractures consists in moulding a piece of binders' board into the form of a gutter, which is padded with cotton and moulded to the palmar or

Fig. 396.



Splints applied to fracture of the phalanx.

dorsal surface of the finger, and held in position by the turns of a narrow bandage or by strips of adhesive plaster.

FRACTURES OF THE PELVIS.

Fractures of the pelvis are not very common injuries. They usually result from falls, from the application of direct force, or from the pelvis being caught between heavy bodies and crushed. The gravity of these injuries depends largely upon whether the pelvic girdle is broken, and upon the presence of injury of the important pelvic viscera. The most serious class of injuries of the pelvis are those which break the pelvic girdle, such as fractures involving the pubis, the sacrum, or the ischium. The less serious are those which involve the crest or spine of the ilium, the margin of the acetabulum, or the tuber ischii, and transverse fractures involving the lower portion of the sacrum. Shock is usually a prominent symptom in fracture of the pelvis.

Complications in Fracture of the Pelvis.—The most serious complications resulting from fracture of the pelvis are injury of the pelvic viscera, such as rupture of the bladder or of the membranous portion of the urethra from displaced fragments of the pubic arch. Laceration of the rectum may also result from fractures of the sacrum or the ischium. In fractures of the bones of the pelvis the condition of the pelvic viscera should be carefully investigated. The vagina and rectum should be examined with the finger: if a laceration of either of these organs is present it may be located, and blood will usually be found in their cavities, and at the same time the position of the fragments may be recognized. The treatment of these complications is considered under injuries of the special organs.

Fracture of the Sacrum.—Fracture of this bone is an uncommon injury unless associated with fracture of other bones of the pelvis. The lower portion is that most liable to fracture, as it is the most exposed portion of the bone.

Causes.—Fracture of the sacrum usually results from concentrated force applied directly to the part, as in falls from a distance where the patient alights upon the sacrum, or where a heavy body comes in contact with this bone. The line of fracture is usually transverse. The displacement consists in an anterior projection of the lower fragment.

Symptoms.—The symptoms in fracture of the sacrum are pain, which is much increased by movements calculated to disturb the fragments, by straining efforts at defecation or urination, or by coughing or sneezing; crepitus may be obtained by manipulation of the fragments; and by the introduction of the finger into the rectum it is often possible to feel the anterior projection of the fragment.

Complications.—The most serious complication in fractures of the sacrum is laceration of the rectum. A force which is sufficient to fracture the sacrum often produces extensive damage to the pelvic organs, aside from the direct contact of the organs with the fractured bone.

Treatment.—The patient should be placed in bed, the thighs being flexed and supported upon a pillow; the rectum should be examined, to ascertain whether it has sustained any injury, and the urine drawn, to ascer-

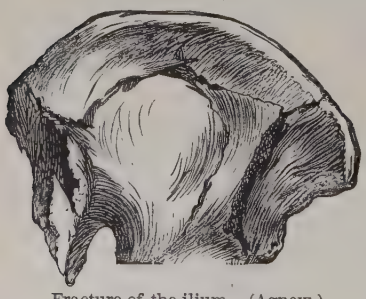
tain whether the bladder has escaped injury. The pelvis should next be surrounded with a stout muslin binder, or broad strips of adhesive plaster should be applied over the ilium on each side, across the sacrum, to produce fixation of the fragments. If the pain is severe, opiates should be administered, and it is well to keep the bowels confined for a few days by their use; at the end of this time they should be moved by an enema, and after they have been freely moved they may be kept quiet again by the same means. In uncomplicated cases the patient should be kept in bed for four weeks. In compound and complicated fractures of the sacrum a much longer period of rest in bed will be required.

Fracture of the Coccyx.—This fracture is not a common one, and results from the application of direct force to the coccyx from kicks, blows, or falls. The displacement is usually forward, and the principal complication following the fracture is a neuralgic affection of the coccyx known as coccygodynia.

Treatment.—This consists in placing the patient in the recumbent posture, in such a manner that no pressure shall be brought to bear upon the coccyx: anterior projection of the fragment may sometimes be relieved by introducing the finger into the rectum and pushing the fragment backward. It is probable that in spite of treatment a certain amount of anterior projection of the fragment always results after fracture of the coccyx. At the end of three weeks the union is usually sufficiently firm to allow the patient to pursue his ordinary occupations.

Fracture of the Ilium.—In fracture of the ilium the line of fracture may separate the crest or the anterior superior spinous process, or it may extend through the body of the bone from the great sacro-sciatic notch forward. (Fig. 397.) Fractures of the ilium are usually produced by falls, or by the pelvis being caught between heavy bodies and crushed.

FIG. 397.



Fracture of the ilium. (Agnew.)

Symptoms.—The most prominent symptom of this accident is pain on motion; the patient is unable to stand or walk, and crepitus may be elicited by grasping the anterior superior spinous process of the ilium and making lateral motion. Where the crest of the bone alone is broken, the detached fragment may be found drawn away from the body of the bone by the action of the abdominal muscles. Where the superior spinous process is broken, it may be drawn downward by the action of the sartorius muscle. In extensive fractures of the ilium the abdominal viscera may be seriously injured.

Treatment.—The patient should be placed in bed upon his back, and the lower extremities flexed by placing pillows under them, the head and shoulders also being supported on pillows to relax the abdominal muscles. The pelvis should be surrounded by a stout binder of muslin firmly secured by pins, or broad strips of adhesive plaster should be passed around the pelvis, producing fixation of the fragments. In compound fractures of the

pelvis the wound should be sterilized, loose fragments of bone removed, and a copious antiseptic gauze dressing applied and held in place by broad strips of adhesive plaster, the patient being kept in bed and the dressings retained for about six weeks.

Fracture of the Pubis.—This fracture results from the same class of injuries that produce fracture of the other pelvic bones, and may involve the horizontal ramus, the descending ramus, or the body. (Fig. 398.) A diastasis of the pubis at the symphysis may also result. Fractures of the pubis are often complicated by injuries of the bladder or the urethra.

FIG. 398.

Fracture of the pubis. (After Agnew.)

Symptoms.—The symptoms of fracture of the pubis are severe pain, increased by attempts at motion or by pressure on the body of the bone, inability to walk or stand, and a feeling on the part of the patient as though he were falling apart. Crepitus and mobility can also sometimes be obtained.

Treatment.—The patient should be placed in bed upon his back, with the thighs flexed, and the pelvis should be supported by a binder of strong muslin, or by broad strips of adhesive plaster, three inches in width, extending entirely around the pelvis. In cases of fracture of the pubis the patient should be kept in bed and the dressings retained for about six weeks.

FIG. 399.

Fracture of the ramus of the ischium. (Agnew.)

Fractures of the Ischium.—Fractures of the ischium are not so common as those of the other pelvic bones, though they sometimes occur in connection with similar injuries of the other bones where great force has been applied. (Fig. 399.) The ischium may be fractured in the course of the ascending ramus, through the tuberosity, or near the acetabulum. Fractures of the ischium are especially liable to occur in falls from a distance, where the weight of the body is received upon the buttocks, and are often complicated by injuries of the urethra, bladder, or rectum.

Symptoms.—The patient is unable to stand or walk, and pain is a prominent symptom. By firmly grasping the tuberosity of the bone mobility and crepitus may be obtained, and rectal or vaginal examination will often disclose the seat of fracture.

Treatment.—The patient should be placed upon his back or side, with the limbs moderately flexed over pillows, and should be kept in bed for six weeks.

Fracture of the Acetabulum.—This fracture may consist in a single fissure or a number of fissures; the lip of the acetabulum may be detached, and in some cases the head of the femur has been driven through the acetabulum into the pelvis. When the lip of the acetabulum is broken, the head of the femur may slip out of the acetabulum when the thigh is rotated. Fractures of the acetabulum may result from violence applied to the sides of the pelvis, or from force transmitted through the femur.

Symptoms.—The symptoms of fracture of the acetabulum are often very obscure, and it may be confounded with fractures of the neck of the femur or dislocations of the head of the bone. Fracture of the posterior lip of the acetabulum, permitting displacement of the head of the femur backward and upward, is especially liable to be confounded with posterior dislocation of the femur.

Treatment.—The patient should be placed upon a firm bed, and an extension apparatus similar to that employed in the treatment of fractures of the femur should be applied to the limb of the injured side. This often relieves the patient's discomfort, and the extension should be continued for at least four or five weeks. Where it is found that the edge of the acetabulum is fractured, the addition of a compress above the fragment, held firmly in place by broad strips of adhesive plaster, will give additional fixation.

FRACTURES OF THE FEMUR.

Fractures of the femur are common injuries, and constitute about six per cent. of all fractures. They occur at all ages, but fractures of certain portions of the bone are met with at different periods of life. Fractures of the shaft of the bone are common in children and adults, of the lower extremity in adults, and of the neck in the aged. Fractures of the femur may involve the upper extremity, the shaft, or the lower extremity.

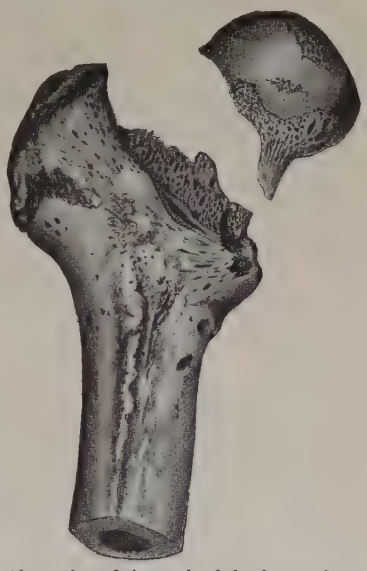
Fractures of the Upper Extremity of the Femur.—These include separation of the upper epiphysis, fracture of the neck, and fracture of the great trochanter.

Separation of the upper epiphysis of the femur is a rare accident, which may occur in patients under eighteen years of age, and is usually the result of force directly applied. The symptoms of this fracture are eversion of the foot, elevation of the trochanter, and crepitus. The *treatment* of separation of the upper epiphysis is similar to that of fracture of the neck of the femur.

Fractures of the Neck of the Femur.—Fractures of the neck of the femur in which the line of fracture is within the insertion of the capsule of the joint are known as *intracapsular* fractures, are peculiar to advanced life, and are most frequent in females. Intracapsular fractures of the femur are by far the most common fractures of the femur which are seen after fifty years of age. It is probable that a large number of the cases classed as intracapsular fractures are really "mixed fractures"—that is, the line of fracture is partly within and partly without the capsule. They often occur as the result of the application of a trivial amount of force, and are peculiar from the fact that bony union is not common. The great frequency of fracture of the narrow part of the neck of the femur in advanced

age from slight violence is probably due to the weakening of the cancellous tissue of the femoral neck from senile atrophy or from fatty degeneration. It is questionable whether there is a marked change in the angular relation of the head and neck of the bone to the shaft in advanced life.

Fig. 400.

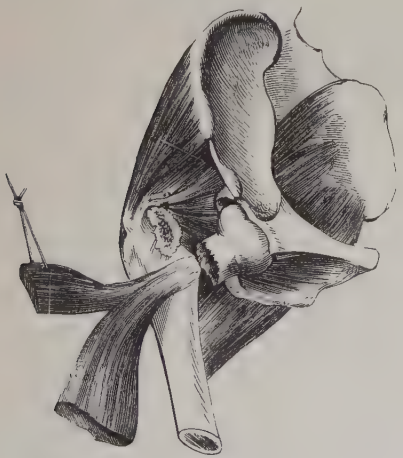


Absorption of the neck of the femur after intracapsular fracture.

Causes.—The exciting cause of fracture of the neck of the femur is usually of a trivial nature; slight falls upon the trochanter or the knee, or twisting of the thigh, in persons of advanced age are often followed by a fracture of the neck of the bone. Fractures of the neck of the femur may be oblique, so that the line of fracture extends through the bone outside of the joint, or there may be impaction of the fragments, so that the lower fragment is driven into and fixed in the substance of the head of the bone. In intracapsular fractures of the neck of the femur, as before stated, bony union does not occur, and there is often more or less absorption of the neck of the bone. (Fig. 400.)

Symptoms.—The most marked signs of intracapsular fracture of the femur are pain, loss of power of the limb, mobility, deformity, and crepitus. Pain, if impaction has not occurred, is acute, is aggravated by muscular spasm, and is relieved by extension made upon the injured limb. The loss of function is marked; occasionally, however, patients are able to perform certain motions at the hip-joint when a fracture is present, which probably results from impaction of the fragments. Mobility in cases of fracture of the neck of the femur is usually increased. Shortening, which is caused by the fragments being driven past each other, varies from half an inch to an inch, but may be progressive and increase gradually for some weeks after the injury.

Fig. 401.



Displacement in fracture of the neck of the femur. (Hines.)

Deformity.—The displacement in fracture of the neck of the femur is due to the action of the glutei muscles, the pectineus, and the adductors, as well as of the psoas, iliacus internus, and obturator externus muscles. The deformity is shown in Fig. 401. Another marked deformity in fracture of the neck of the femur is eversion of the foot, from external rotation of the limb.

This deformity is due to the action of the external rotator muscles, to the absence of resistance in the ligamentum teres, and to the action of gravity, as the centre of gravity of the leg and thigh lies outside of the centre of figure of the limb. Eversion of the foot may not be present in cases of impacted fracture of the neck of the femur. Crepitus may be elicited in the majority of cases of unimpacted fracture, by making extension upon the leg, flexing the thigh at right angles with the pelvis, and rotating the limb. If other symptoms of fracture of the femur are present, it is not advisable to make forcible prolonged efforts to obtain crepitus, as by so doing the periosteum may be torn, or the impacted fracture may be liberated and greater deformity result. Allis has called attention to a sign of fracture of the neck of the femur which consists in the existence of a relaxed condition of the fascia lata between the crest of the ilium and the trochanter major on the injured side, due to the loss of resistance which is normally furnished by the unbroken neck of the bone. This is a valuable diagnostic sign in this fracture.

Prognosis.—In cases of intracapsular fracture, as they usually occur in aged persons, the prognosis is generally grave, since bony union practically never occurs, so that the functional result following the fracture is always imperfect. Many patients suffering from this fracture die from exhaustion following the confinement to bed and the occurrence of bed-sores. The causes of non-union in intracapsular fractures of the femur are probably deficient vascularity, the presence of synovial fluid in contact with the reparative material, and the imperfect coaptation of the fragments. The most satisfactory results occur in those cases in which the line of fracture not only involves the neck of the bone, but extends to the bone outside of the neck. In these cases there is enough reparative material deposited outside of the capsule to give a certain amount of fixation. There are, however, occasionally seen cases of intracapsular fractures of the femur in which patients recover with fairly useful limbs in spite of considerable shortening.

Treatment.—As it is impossible in any case of fracture of the neck of the femur to say that the fracture is entirely within the capsule, it is wise to treat the patient as though there were a prospect of bony union. As these fractures occur in patients well advanced in years, and as such cases frequently do not bear the application of retentive apparatus well, the surgeon has often to consider the patient's constitutional condition more than the local injury, and has practically to disregard the treatment of the fracture and get the patient up and about as a means of improving his general condition. We have seen very excellent results in cases of fracture of the neck of the femur in which the patient was allowed to remain in bed, changing the position as often as was desired, for three or four weeks, no retentive dressings being applied.

The dressing which we would recommend in cases of fracture of the neck of the femur is an extension apparatus, which is made by taking a strip of adhesive plaster two and a half inches in width and long enough to extend from the knee-joint down the leg to two or three inches below the heel, forming a loop; it is then carried to the other side of the limb and extends as high as the knee-joint. Some surgeons prefer to carry the ex-

tension strips of plaster well up on the thigh, fearing that if they extended only to the knee-joint the ligaments would be injured, but in using the strips only to the knee in a large number of cases we have never found any damage to result. A block of wood about five inches in length and three inches in width is fastened to the middle of this strip of plaster, and is secured in position by a short strip of plaster of the same width, about twelve inches in length. This block is secured by wrapping it with a few strips of plaster. The strip of plaster, being heated, is attached to the outer and inner sides of the leg from the knee to just above the malleoli. It is secured by three bands of plaster carried around the leg, one applied just above the malleoli, the second about the middle of the leg, and the third just below the knee. A roller bandage is applied to the foot and leg, to give additional fixation to the plaster. (Fig. 402.) A

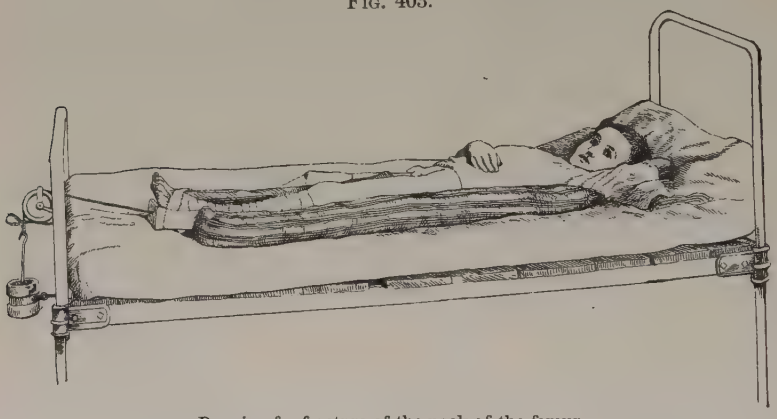
Fig. 402.

Application of the extension apparatus.

piece of cord is next secured in a perforation in the block below the foot. The patient being placed in the recumbent position in bed upon a firm mattress, lateral support is given to the limb by means of a short internal sand-bag extending from the perineum to the sole of the foot, and a long external sand-bag extending from the axilla to the external malleolus. Eversion of the foot is corrected by rotating the thigh inward, and the corrected position is maintained by apposition of the external sand-bag. A weight of from five to eight pounds is attached to the cord and secured to the block in the extension apparatus. (Fig. 403.) If this dressing is well borne, it should be kept in position for from four to six weeks; the patient should then be allowed to sit up in bed, and finally to get out of bed and use crutches, bearing at first very little weight upon the injured limb. If, however, the recumbent posture and the confinement in bed affect the patient unfavorably before this period, it may be necessary to abandon all

treatment and to allow him to sit in a chair or to use crutches, the treatment of the fracture for the time being disregarded. It is remarkable in some cases, even of persons far advanced in years, how much use of the limb the patient may regain after this fracture.

Fig. 403.



Dressing for fracture of the neck of the femur.

Extracapsular Fractures of the Neck of the Femur.—These present many points in common with fractures occurring within the capsular ligament. Extracapsular fractures of the neck of the femur are produced by blows or falls upon the trochanter, or by violence transmitted through falls upon the knee or the foot. The line of fracture may be transverse, involving the lower portion of the neck of the bone and the trochanter, or oblique, involving the neck of the bone and the upper portion of the shaft. Comminution also may occur, so that three or more fragments are produced. Fractures of the neck of the bone outside of the capsule may be impacted, the neck being driven into the cancellated tissue of the trochanter and the shaft of the femur. In the repair of extracapsular fractures of the neck of the femur the amount of callus thrown out is usually very large. (Fig. 404.)

Fig. 404.

Excessive callus after extracapsular fracture of the neck of the femur. (Agnew.)

Symptoms.—The symptoms following this injury are very similar to those following fracture within the capsule of the joint, and consist of pain, swelling, discoloration, disability, crepitus, and deformity. The deformity is usually greater than that following intracapsular fractures of the neck of the femur. Crepitus cannot be obtained where there is firm impaction, but can be elicited when the fragments are loose, by rotating the thigh. Deformity in this fracture consists in shortening of from one-quarter of an inch to two or three inches. Eversion of the foot is usually present, except in cases of impaction, when instead of eversion there may be inversion of the foot. Extracapsular fractures of the neck of the femur result from great

violence applied to the trochanter; there is more or less swelling and bruising of the tissues in this region, and on comparing the injured trochanter with its fellow it will be found that it is much broader, and rotation is limited.

Diagnosis.—The injury which is most apt to be confounded with fracture of the neck of the femur, either extracapsular or intracapsular, is posterior dislocation of the femur. Fracture of the neck of the femur is usually produced by trivial force or by force applied directly to the trochanter. Posterior dislocation usually results from great force applied to the knee while the thigh is adducted. Fracture of the neck of the femur occurs most commonly after fifty years of age and most frequently in females; posterior luxation of the femur is more likely to occur in adult males before fifty years of age. In fracture the limb is markedly everted, unless there be impaction, and in dislocation inversion and adduction of the thigh are present. The shortening in fracture is at first trivial, and may be from one inch to two inches. In posterior dislocation the shortening is often three or four inches. In fracture the shortening can be reduced by extension, but recurs on the removal of the extending force. In dislocation, when the shortening is reduced by replacing the bone, on the removal of the extending force it does not recur. In fracture there is great mobility, while in dislocation the limb is fixed and rigid. Crepitus may often be obtained in fracture; in dislocation there is no true crepitus.

Treatment.—The treatment of extracapsular fractures is similar to that for intracapsular fractures.

Fracture of the Great Trochanter.—This consists in a separation of the great trochanter from the shaft of the femur, and usually results from direct violence, such as falls upon this portion of the bone. In patients under eighteen years of age the injury may consist in a separation of the epiphysis.

Symptoms.—The most marked symptoms will be swelling in the region of the trochanter, pain, tenderness, and mobility of the fragments elicited by manipulation; crepitus also may be obtained. There will be no shortening of the thigh, and movements of the hip may be but slightly impaired.

Treatment.—The treatment consists in fixation of the limb by the use of sand-bags; if there is pain from contusion of the joint produced at the time of the injury, this may be relieved by the application of the extension apparatus, such as is employed in cases of fracture of the neck of the femur.

Fractures of the Upper Third of the Femur.—These fractures are often accompanied by marked deformity, and their treatment is difficult, owing to the fact that the upper fragment is often displaced forward and upward by the action of the psoas and iliacus internus muscles, or outward by the action of the gluteus minimus, obturator internus, and quadratus femoris muscles. (Fig. 405.) The greatest difficulty experienced in the treatment of these fractures arises from this displacement of the upper fragment, which may lead to marked shortening, angular deformity, and consequent impairment of the use of the limb.

Treatment.—In the treatment of fractures of the upper third of the femur, in the majority of cases the dressing which will be described for frac-

tures of the shaft may be employed with satisfactory results, but occasionally cases are met with in which the upward and inward tilting of the upper fragment is so marked that a different kind of dressing has to be resorted to. In such cases, where it is impossible to bring the upper fragment in contact with the lower one, the surgeon may find it advisable to apply a dressing which will bring the lower fragment in the line of the upper fragment. This may be accomplished by using the anterior wire splint of Professor N. R. Smith (Fig. 406), or by placing the leg and thigh upon a double inclined plane and applying an extension apparatus to the thigh from the knee to a point a little below the seat of fracture, extension being made by a weight and pulley, as shown in Fig. 407, and lateral support supplied either by the use of short moulded splints or by movable sides attached to the double inclined splint.

Fig. 405.

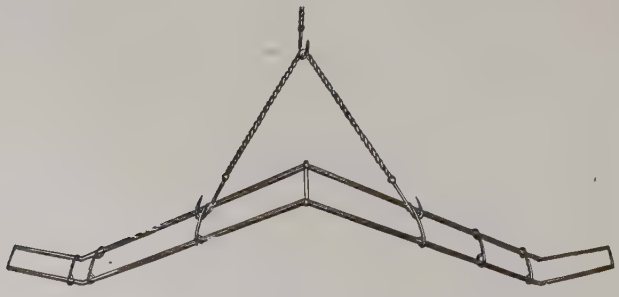
Displacement in fracture of the upper third of the femur. (Agnew.)

Fractures of the Shaft of the Femur.—Fractures of the shaft of the femur are common injuries, and are most frequent before ten years of age. The line of fracture may be transverse or oblique. Transverse fractures of the femur are most common in children, oblique fractures in adults.

Causes.—These fractures may occur from direct violence, as the result of the passage of heavy bodies over the thigh, or may result from indirect violence, from force transmitted through the foot and leg. Muscular action may also produce fracture of the shaft of the femur.

Symptoms.—The symptoms of fracture of the shaft of the femur are pain, increased by movements or by muscular contraction; mobility, which may be demonstrated by raising the leg or thigh, and by adduction or abduction; and deformity, which consists in shortening, with a prominence upon the anterior portion of the thigh

Fig. 406.

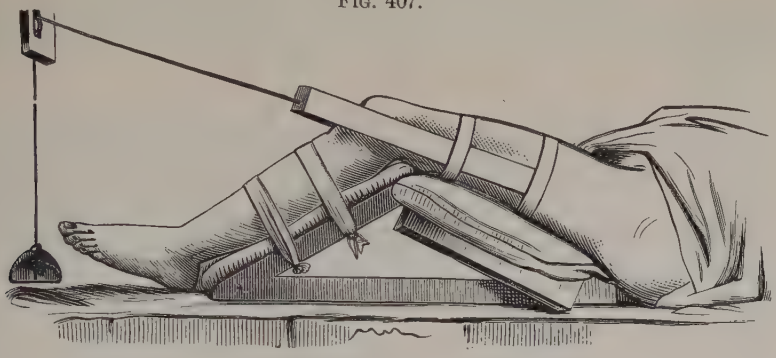


Smith's anterior wire splint.

(Fig. 408), or may consist of marked angular displacement of the fragments and eversion of the foot. The shortening may not be marked in transverse

fractures of the femur, or in indented fractures in which the irregular projections of the fragments are interlocked. Crepitus may be easily elicited by rotating the thigh. In fracture of the shaft of the femur the disability is marked, the patient usually being unable to move the limb.

Fig. 407.



Double inclined plane. (Agnew.)

Prognosis.—In cases of simple fracture, without complications, a good result generally follows. The results of this fracture in children are usually favorable as regards recovery with very little shortening. In adults, however, a certain amount of shortening always occurs, varying from a quarter of an inch to an inch and a half. Agnew states that in fracture of the femur, except in cases of children, an appreciable shortening always results.

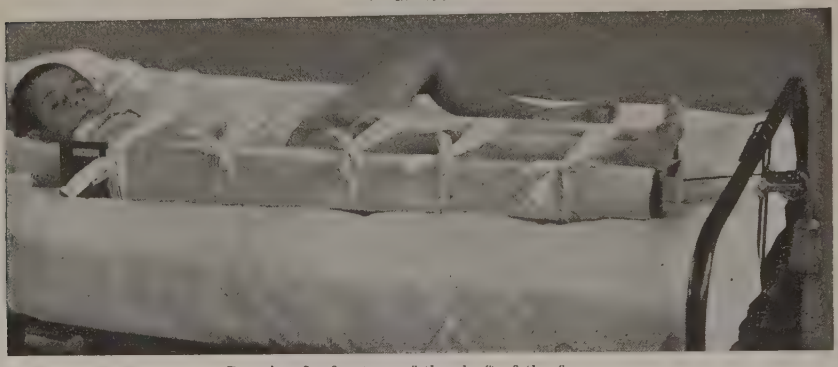
Fig. 408.

Deformity in fracture of the shaft of the femur. (Agnew.)

Treatment.—In the treatment of this injury the dressings are applied so as to diminish as far as possible the shortening, and to prevent angular or rotatory displacement of the fragments. The patient should be placed in bed upon a firm mattress; an extension apparatus of adhesive plaster is applied, and a weight is attached to this, as previously described under fractures of the neck of the femur. Lateral support is given to the limb by the application of two wooden splints, the outer or longer one extending from the axilla to the foot, the inner or shorter one extending from the groin to the foot. The upper extremity of each should be about six inches in width, and the lower extremity about three and a half inches. The splints should be wrapped in a splint-cloth which extends from the foot to the groin, and after this has been placed under the limb they are fixed in their positions, the short one to the inner side, the long one to the outer side, of the limb. Between the limb and the splints bran-bags should be interposed; the outer one should be long enough to extend from the axilla to the foot, and the inner one from the groin to the foot. The splints and bran-bags should next be held in position by five or six strips of bandage

passed at intervals under the limb and body and around the splints and bran-bags. (Fig. 409.) The heel is saved from pressure by placing a pad of oakum or cotton under the tendo Achillis, and after the splints have been brought into place the strips of bandage are firmly tied, and a weight of ten or twelve pounds is attached to the extending cord. The foot of the bed is raised, to prevent the patient from slipping downward, and to allow the weight of the body to act as a counter-extending force.

Fig. 409.



Dressing for fracture of the shaft of the femur.

Volkmann's slide may be employed to hold the foot in place and to make the extension more effective. After the application of the dressing the thigh should be slightly abducted. During the after-treatment of fractures of the shaft of the femur the surgeon should see that the splints and bran-bags are kept firmly in place and that the foot does not roll outward. This is accomplished by untying the strips and readjusting the bags, and then bringing up the splints and securing them in position by fastening the strips. The extension apparatus does not require renewal during the course of treatment. The extension apparatus and splints are kept in position for from four to six weeks. At the end of this time union at the seat of fracture is usually quite firm, so that they may be removed, and the fracture may then be supported by moulded pasteboard splints, or by the application of a plaster of Paris splint, for several weeks longer. At the end of eight weeks it is safe to allow the patient to be up and about on crutches. Lateral support in fractures of the shaft of the femur may also be supplied by the use of a long external sand-bag and a short internal one, in place of the corresponding long and short splints and bran-bags. If care is taken that the sand-bags are kept accurately in contact with the limb and body, excellent results may be obtained by this form of dressing. After considerable experience with different methods of furnishing lateral support in fracture of the shaft of the femur, we are satisfied that angular deformity is less likely to result where the splints and bran-bags are employed. The plaster of Paris dressing, including the foot, leg, thigh, and pelvis, is employed by some surgeons in this fracture, the limb being kept well extended until the plaster is thoroughly dry. This dressing is also applied in the ambulant method of treatment, which will be described later.

Fracture of the Shaft of the Femur in Children.—Fractures of the shaft of the femur in young children are often incomplete or "green-stick" fractures, and even when complete the shortening is usually not marked, as the line of fracture is apt to be transverse, and the periosteum often, not being completely ruptured, tends to hold the fragments in position. In cases, however, in which the periosteum is extensively torn, marked displacement and shortening may occur, as is shown in the specimen, taken from a child eighteen months of age, two weeks after a fracture which had not been treated. (Fig. 410.) In incomplete fractures with deformity, the latter should be reduced by manipulation and pressure, even if it is necessary to convert the incomplete fracture into a complete one to accomplish this object.

FIG. 410.

Fractured femur of a child of eighteen months, two weeks after the injury.

Treatment.—The treatment of these fractures in young children by extension and lateral splints is sometimes troublesome, on account of the difficulty in keeping the patient quiet upon his back and from the soiling of the dressing by feces and urine. In children two years of age and over we have never found much trouble in employing extension and lateral support by splints and bran-bags or sand-bags, and have used this method in younger children, but in these cases we make additional fixation at the seat of fracture, and guard against displacement of the fragments by the child's sitting up in bed when not carefully watched, by moulding and applying well-padded internal and external pasteboard or binders' board splints to the thigh and holding them in place by the turns of a bandage. These fractures may also be dressed according to Bryant's method, by suspending both legs from a gallows over the bed so as just to lift the sacrum from the bed, or a plaster of Paris bandage from the foot to the waist may be employed. In cases of fracture of the femur in children eighteen months of age or under, it is often difficult to keep them in a fixed position, or they may have to be moved to give nourishment if they are taking the breast. In such cases the dressing which we have found most satisfactory consists in applying a roller bandage from the foot to the groin, and then moulding to the outer half of the foot, leg, thigh, and pelvis a binders' board splint, which is well padded with cotton and held in position by the turns of a bandage carried from the foot to the pelvis and finished with circular turns about the latter. This splint should be moulded so as to include a little more than one-half the circumference of the thigh and leg. If the splint becomes soiled it is easily replaced by a fresh one, and its removal and renewal are much easier than is the case with the plaster of Paris dressing.

Supracondyloid Fractures of the Femur.—*Supracondyloid fractures of the femur* may occur just above or at some distance from the condyles. The *treatment* of supracondyloid fractures is similar to that employed in cases of fractures of the shaft of the femur.

Separation of the Lower Epiphysis of the Femur.—This accident occurs in children or in patients under eighteen years of age, and is usually produced by forcible twisting of the leg. The deformity generally consists in the epiphysis being carried forward and the end of the shaft of the femur being forced backward into the popliteal space, where it may injure the vessels and nerves. (Fig. 411.) The majority of cases of separation of the lower epiphysis of the femur which have come under our observation have occurred from the leg being thrust between the spokes of a moving wheel, and have usually been cases of compound separation of the epiphysis, with injury of the vessels and nerves, requiring amputation.

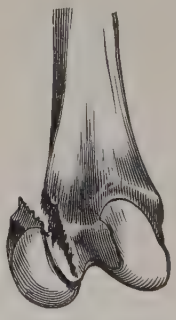
Fig. 411.

Separation of the lower epiphysis of the femur. (Hamilton.)

Treatment.—The treatment of separation of the lower epiphysis of the femur consists in reduction of the deformity by manipulation and the application of an extension apparatus to the leg, with lateral support to the leg and thigh by the use of padded splints or sand-bags, or in the application of a plaster of Paris bandage.

Fractures of the Condyles of the Femur.—These fractures are usually produced by blows or falls upon the knee. The line of fracture may pass between the condyles, separating one condyle from the shaft (Fig. 412), or both condyles may be separated, and the shaft of the bone may occupy a position in front of them. In condyloid fracture the most serious complications are involvement of the knee-joint and injury to the vessels and nerves in the popliteal space.

Fig. 412.



Fracture of the external condyle of the femur. (Agnew.)

Treatment.—In these fractures the reduction is effected by flexing the leg upon the thigh, at the same time making extension, carefully avoiding all rough movements for fear of the displaced fragments injuring the popliteal nerves or vessels. After the deformity has been reduced the extension apparatus should be applied to the leg, and lateral support should be furnished by means of splints and bran-bags or by sand-bags. If one condyle only is separated, the uninjured condyle prevents shortening, and the extension apparatus is not required. The leg and thigh may then be placed in a long fracture-box, and a compress placed over the injured condyle to hold it in position, or a plaster of Paris bandage, including the foot, leg, and thigh, may be employed in the place of the latter dressing. The results following fractures of the condyles of the femur are usually not satisfactory; the involvement of the knee-joint is apt to lead to permanent stiffness or ankylosis of the joint, and it is, therefore, important that the limb should be kept as nearly as possible in the extended position in case this complication should follow.

The Ambulant Treatment in Fractures of the Femur.—This treatment has recently been recommended and practised in Germany and in this country with apparently good results, and consists in applying a

plaster of Paris splint to the foot, leg, and thigh, extending from the metatarsal bones to the tuber ischii. In applying the plaster of Paris bandage in the ambulant treatment of these fractures the foot is placed at a right angle to the leg and is well padded with a number of layers of cotton; the plaster of Paris bandage is then applied directly to the skin from the metatarsal bones to the knee, five or six thicknesses of bandage being employed; this is allowed to become partially firm; the patient is then placed with the pelvis elevated, and extension is made from the plaster cast and by pulling upon the chest from above. When the deformity has been corrected and the legs are of equal length, a plaster of Paris dressing is applied from the knee to the tuber ischii and the gluteal folds, and turns of the bandage are made, so as to include the thigh and extend as far as the anterior superior spine of the ilium. Oblique turns of the bandage are made from the thigh over the lower portion of the abdomen and back again to the thigh, and the plaster bandage may be strengthened by narrow strips of veneer or basswood splinting incorporated with the layers of plaster. The extension is maintained upon the limb until the plaster bandage has firmly set. The patient is allowed to get up upon the following day, and to walk, first with crutches, then with a cane, and finally without either of these appliances, placing his weight upon the foot of the injured leg. We do not think that this method of treatment of fractures of the thigh is to be recommended unless the surgeon has the patient under constant supervision.

Compound Fractures of the Femur.—Compound fractures of the femur involving any portion of the bone are most serious injuries, and in many cases where the main blood-vessels are injured, or where there is much comminution of the bone or involvement of the knee-joint, primary amputation or excision may be required. However, if the main blood-vessels have escaped injury, and the wound is carefully sterilized and good fixation of the fragments can be secured, many cases recover with useful limbs. If it is found that there is comminution, and there are present in the wound loose fragments, these should be removed. We had recently under our care a compound comminuted fracture of the femur in which a fragment an inch and a half in length was entirely separated. This was removed, and the patient made a good recovery, with a proportionate amount of shortening. In cases of compound fracture of the femur where amputation is not considered, the patient should be anæsthetized, and, after carefully sterilizing the wound and reducing the displacement by extension and manipulation, primary fixation of the fragments should be made by drilling the bone and securing the fragments in position by heavy silver wire sutures, or by the use of perforated silver splints secured by screws. The wound should then be drained and closed by a few sutures. A copious antiseptic dressing should be applied, and fixation of the fragments at the seat of fracture, as well as of the leg, the knee-joint, and the hip-joint, secured by the application of a plaster of Paris dressing extending from the foot to the pelvis. If for any reason the plaster of Paris dressing is not considered advisable after the dressing of the wound, a dressing similar to that employed in simple fractures of the shaft of the femur, consisting of extension and lateral support by means of bran-bags and splints, or sand-bags, may be applied.

FRACTURES OF THE PATELLA.

Fractures of the patella are rarely seen in patients under twenty years, and are not common after fifty years of age. Fractures of this bone may be simple, compound, or comminuted, and result from direct violence and muscular action. The direction of the fracture may be transverse, vertical, or oblique.

Fig. 413.

Displacement of the fragments in fracture of the patella. (Agnew.)

Symptoms.—The symptoms of this injury are pain, loss of power of extending the leg, a considerable amount of swelling about the knee-joint, and an upward displacement of the upper fragment by the action of the quadratus muscle: often, also, a marked depression can be felt with the finger between the fragments. (Fig. 413.) Hutchinson is of the opinion that displacement of the fragments is as much due to the pressure of the effusion into the knee-joint as to muscular action. The separation of the fragments may vary from a fraction of an inch to several inches. (Fig. 414.) Patients suffering from fracture of the patella are not always incapacitated from using the limb. Crepitus can usually be obtained by drawing the upper fragment downward in contact with the lower fragment and making lateral motion. Marked swelling of the knee occurs rapidly after this fracture, as the joint becomes distended with synovial fluid and blood. Comminuted fractures of the patella usually result from force directly applied to the front of the knee, as from falls, or from the kicks of horses.

Fig. 414.

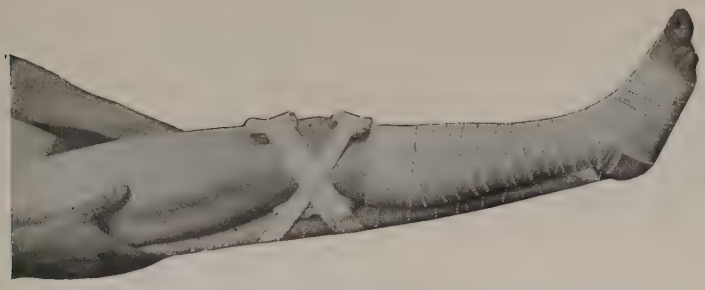
Deformity in fracture of the patella.

Prognosis.—In fracture of the patella union is usually ligamentous, although cases have been recorded in which bony union has resulted. The bond of union may be short or long; a ligamentous bond of three or four inches has been noted. The function of the limb is generally more or less impaired as the result of this fracture. Rigidity of the joint is often marked and may persist, and union by a long fibrous band may interfere seriously with the extension of the leg. In other cases the patient may have a fair functional result in spite of union by a long fibrous band. In most cases rigidity of the joint or weakness of the knee is present. The results as regards function depend largely upon the extent of the rupture of the tendinous expansion of the quadriceps, the amount of effusion of blood into the joint, and the interposition of the capsular tissues between the fragments.

Treatment.—The limb should be placed in the extended position, and a roller bandage applied from the toes to a point just below the knee joint. A posterior wooden padded splint, extending from the middle of the thigh to the middle of the leg, should then be placed under the limb, and a compress placed just above the upper fragment, and over this should be applied, obliquely, one or two straps of adhesive or rubber plaster, which are carried downward and attached to the posterior splint some distance below the

position of the upper fragment; the lower fragment should also be fixed by a compress and oblique strips of plaster, applied in the opposite direction and secured to the splint above. (Fig. 415.) A bandage should then be

Fig. 415.



Application of splint, compresses, and strips in fracture of the patella.

applied to fix the splint firmly to the leg and thigh, being carried over the knee and to the upper end of the splint (Fig. 416); or an Agnew's splint, which consists of a posterior splint with pegs, around which the ends of the adhesive plaster applied above and below the ends of the fragment are fastened, may be employed. After the application of the splint and bandage the limb should be elevated and placed upon an inclined plane or in a fracture-box the lower end of which has been elevated, in order to relax the rectus muscle. This dressing is usually retained for from four to six weeks,

Fig. 416.

Dressing for fracture of the patella.

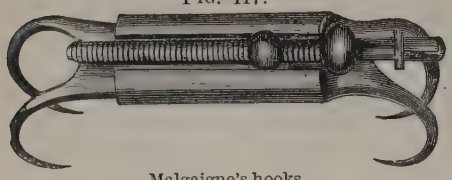
at the end of which time there is generally firm fibrous union at the seat of fracture. The splint should then be removed, and a plaster of Paris bandage applied extending from the middle of the leg to the thigh, and retained for several weeks.

Fixation by Sutures.—Another method of treatment in fracture of the patella consists in exposing the fragments by an incision with full antiseptic precautions, and introducing heavy silver wire sutures to secure apposition of the fragments, or in the employment of Stimson's method, in which the capsule and the periosteum are sutured with catgut. These methods have been practised with success, and apparently in some cases bony union has been secured. The question of exposing and wiring the fragments in cases of fracture of the patella is one which has to be decided in individual cases. The results obtained by the more conservative methods of treatment are usually reasonably satisfactory, and it is to be remembered that there is a definite amount of risk in exposing the patella and opening the joint. No one

is justified in suturing a fractured patella unless he is in a position to do an operation in which every aseptic detail can be carried out.

Malgaigne's Hooks.—A method of treatment which apparently gives as good results as the suturing of the patella, and which is accompanied by no greater risk, is that of approximation of the fragments by means of Malgaigne's hooks. (Fig. 417.) In applying this treatment the skin in the neighborhood of the knee should be thoroughly sterilized; punctures are made down to the fragments with a tenotome, the hooks are placed in position in the lower and upper fragments, and the fragments are then brought together by turning the screw which approximates the hooks. An antiseptic dressing is applied over the hooks, and they are allowed to stay in position for two or three weeks; at the end of this time they are removed, and the leg is dressed with a plaster of Paris dressing, which is retained for from four to six weeks.

FIG. 417.



Malgaigne's hooks.

Circumpatellar Suture.—Another method of treatment which has recently been employed with success is the circumpatellar subcutaneous suture, recommended by Mr. Barker, which consists in making a puncture through the ligamentum patellæ with a tenotome and passing through this puncture a heavy curved needle with an eye near its point, which is passed under the patella, transfixing the tendon of the quadriceps, and is then brought out through the skin; this is threaded with a heavy silk or silver wire suture and is withdrawn; the needle is again passed through the same puncture and passed over the patella, and its point is made to emerge through the original puncture in the skin below the patella. The other end of the ligature is then threaded into the needle, and it is withdrawn; the ends of the suture are then securely tied by several knots, which are buried in the wound, the ends being cut off. The small wounds are closed by compresses of antiseptic gauze, and the limb is placed upon a posterior splint or in a plaster of Paris dressing. In this operation it is essential that all aseptic details should be most carefully observed.

Compound Fractures of the Patella.—Compound fractures of the patella are most serious injuries, and should be treated by first thoroughly sterilizing the wound and removing all loose fragments, then introducing heavy wire sutures to secure the fragments in apposition, and following this procedure by suture of the capsular structures with catgut and the introduction of a drainage-tube. The wound should be closed and dressed with a copious antiseptic dressing, and fixation of the leg in the extended position should be maintained by the application of a posterior splint or by a plaster of Paris dressing.

FRACTURES OF THE BONES OF THE LEG.

Fractures of the Tibia and Fibula.—Fractures of both bones of the leg are common accidents, and may result from force directly applied, as in the case of heavy bodies falling upon the leg, or the kicks of horses, or the

passage of wheels over the leg; or from indirect injury, as falls from a height, where the violence is applied to the foot. When produced by direct force the fracture occurs at the seat of application of the violence, and the line of fracture is likely to be more or less transverse. Fractures of both bones of the leg when produced by indirect force are usually oblique, and the two bones are seldom broken at the same level.

Symptoms.—The symptoms of this fracture are pain, deformity, mobility, and crepitus. The deformity depends upon the degree of displacement of the fragments, and may consist in an anterior projection of the upper end of the lower fragment, in lateral displacement, or in overlapping of the fragments. When the force producing the fracture is applied to the front of the leg, the line of separation may be from below upward and from before backward, in which case the lower fragment will assume a position behind the upper one.

Treatment.—In the treatment of fractures of both bones of the leg, where there is marked tilting of the upper end of the lower fragment, and the deformity persists in spite of ordinary methods of treatment, it can often be remedied by making a subcutaneous section of the tendo Achillis; extension and counter-extension should be made, and the leg placed in a fracture-box padded with a soft pillow, the foot being kept at a right angle to

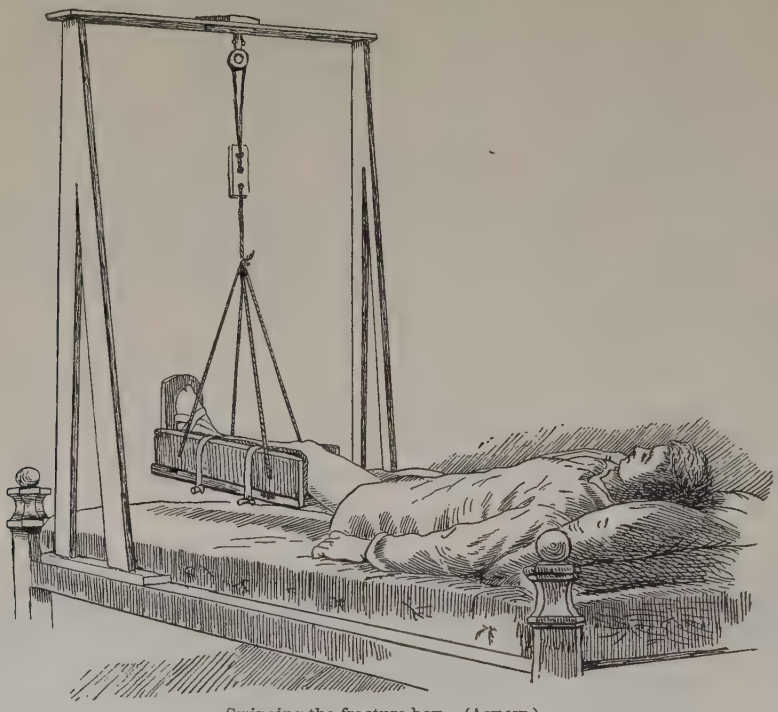
FIG. 418.

Dressing of fracture of both bones of the leg in a fracture-box.

the leg, and brought in contact with the bottom of the box and secured to the foot-board by a strip of bandage; a compress should be placed under the tendo Achillis, and the sides of the box brought up and secured by strips of bandage. (Fig. 418.) The principal objection to the use of the fracture-box is that in the case of a restless patient the movements of the body may cause the foot to press against the foot-board and thus produce overlapping of the fragments. We have found that the swinging of the box by a frame over the bed will prevent this complication and allow the patient to change his position slightly, and will at the same time be a most comfortable dressing. (Fig. 419.) Many surgeons prefer to treat fractures of both bones of the leg by the immediate application of a plaster of Paris dressing. This can be done with perfect safety if the patient can be kept under obser-

vation ; but if there is a great amount of swelling when the plaster of Paris dressing is applied, the dressing should be removed at the end of a week or

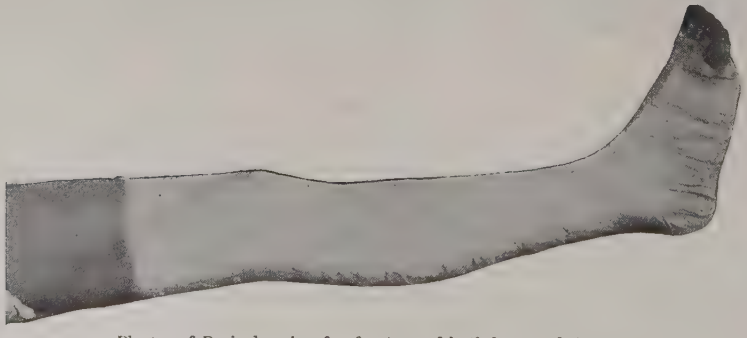
Fig. 419.



Swinging the fracture-box. (Agnew.)

ten days and a fresh one applied. We usually employ the fracture-box in the treatment of fracture of both bones of the leg for ten days or two weeks, and at the end of this time apply a plaster of Paris bandage, including the foot and leg and extending a short distance above the knee-joint. (Fig.

Fig. 420.



Plaster of Paris dressing for fracture of both bones of the leg.

420.) At the end of six weeks union is generally quite firm ; but the patient should not be allowed to support his weight upon the injured leg until at least eight weeks have elapsed after the injury.

Fractures of the Tibia.—These include separation of the upper or lower epiphysis and fractures involving any portion of the shaft of the bone. (Fig. 421.) Fractures of the head of the tibia may involve the knee-joint, those of the lower portion may involve the ankle-joint, and both are produced by force directly applied, or by indirect force, the violence being transmitted through the foot.

Fig. 421.

Fractures of the shaft and lower end of the tibia.

Symptoms.—In fractures of the shaft of the tibia alone there is usually very little displacement, the fibula acting as a splint to prevent shortening, but some little displacement may often be discovered by passing the finger along the spine of the bone. Crepitus can usually be elicited by grasping the tibia above and below the seat of fracture and making motion. Fractures of the upper portion of the bone which involve the knee-joint are followed by effusion into the joint. In *epiphyseal separation* of the lower end of the tibia, an important diagnostic sign is that the internal malleolus preserves its natural relation to the foot, but not to the leg.

Treatment.—Fractures of the shaft of the tibia may be treated by the use of the fracture-box, as described in the treatment of fractures of both bones of the leg, or by the application of a plaster of Paris dressing. The results following the treatment of this fracture are usually very satisfactory, as little shortening occurs, from the fact that the fibula prevents overlapping of the bone. Where the fracture involves the ankle-joint or the knee-joint, great care should be taken to reduce the fragments as completely as possible and to secure fixation of the parts above and below the seat of fracture. In such cases a certain amount of ankylosis of the ankle- or knee-joint may result, and after three or four weeks passive motion should be instituted to preserve mobility of the joint.

Ambulant Treatment of Fractures of the Bones of the Leg.—This method of treatment has recently been recommended and practised with good results. In employing this method, the leg having first been thoroughly washed with soap and water, extension should be made to reduce the deformity, and the foot placed at a right angle to the leg; a flannel bandage should next be applied from the toes to a short distance above the knee. Cotton wadding should be freely applied around the foot and the malleoli, and a plaster of Paris bandage carried from the base of the toes to a point a short distance above the knee-joint, being made especially firm just below the knee and at the sole of the foot and the ankle. The sole should also be strengthened by a number of longitudinal layers of the bandage, extension being kept up upon the leg until the plaster of Paris bandage has completely set. The patient is permitted to get up as soon as the plaster is firm, and

allowed to walk, first with crutches, then with a cane, and finally supporting his weight upon the injured limb. The theory upon which this dressing is used in fractures of the bones of the leg is that the limb is suspended in the plaster cast, and that really no weight is brought to bear upon it; the weight is transmitted to the plaster cast, and the points of pressure are just below the head of the tibia and the condyles of the femur. The advantages claimed are that the patient can soon be about and attend to his business, and that there is little swelling, as the fragments are thoroughly immobilized. Excellent results have followed this method of treatment, but we think it should be employed only where the surgeon has the patient under continuous observation.

Compound Fractures of the Bones of the Leg.—Compound fractures of the bones of the leg are common injuries, and the line of fracture may be similar to that seen in simple fractures. The greatest danger is from infection of the wound, and the risk of infection is greater if the wound is made from without than if made by the fragments from within.

Treatment.—The treatment of compound fractures of the bones of the leg consists, first, in the sterilization of the skin surrounding the wound and of the wound itself; loose fragments of bone or foreign bodies should be removed, and it is wise in all cases, except those in which only a small punctured wound exists and in which there is no comminution of the bones, to fix the fragments by the application of heavy silver wire sutures; the wound should then be drained, a few superficial sutures introduced, and a copious antiseptic dressing applied. The ankle-joint and the knee-joint should be fixed by the use of a fracture-box, or by the application of moulded pasteboard splints extending from the sole of the foot to a point a little above the knee-joint. A plaster of Paris dressing may be applied in these cases, provision being made at the time of its application for fenestrating the bandage over the seat of fracture, if for any reason it should become necessary to expose the wound. The time required for union in cases of compound fractures of the bones of the leg is considerably longer than that required in simple fractures, being from twelve to sixteen weeks. In compound fracture of the leg, Treves, after sterilizing the skin and the wound, keeps the parts dusted with powdered iodoform, and as this mixes with the serum and blood and dries, an antiseptic scab covering the wound results.

FRACTURES OF THE FIBULA.

Fractures of the fibula may occur at the upper extremity, in the shaft, or at the lower extremity of the bone; the most common seat of fracture is in the lower third. These fractures are produced by direct or by indirect force. When produced by direct force, such as a blow, the wheel of a wagon, or the kick of a horse, the fracture will usually be found to occur at the point where the force is applied. When produced by indirect force, the bone usually gives way in its lower third, within two and a half or three inches of the inferior extremity.

Fracture of the Upper End of the Fibula.—Fracture of the upper end of the fibula may be caused by direct force, by sudden contraction of the biceps muscle, or by forcible adduction of the leg. In such cases

the fragments are usually not much displaced, but the upper one may be drawn slightly upward by the biceps. Fracture of the upper end of the fibula may be complicated by injury of the popliteal nerve, or later impairment of the function of this nerve from its implication in the callus.

Treatment.—The treatment of fracture of the upper end of the fibula consists in immobilization of the leg by the use of a fracture-box, and the same result may be secured by the application of a plaster of Paris bandage, which fixes the ankle and the knee. If displacement in the upper fragment is marked, from contraction of the biceps muscle, flexion of the knee before the application of the plaster of Paris dressing will often correct this deformity.

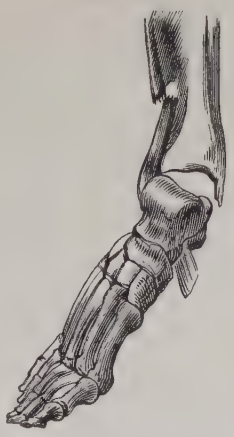
Fracture of the Shaft of the Fibula.—The displacement in fractures of the shaft of the fibula usually consists in a tilting forward of the lower end of the upper fragment. This fracture can usually be recognized by the presence of pain, mobility, and crepitus.

Treatment.—In the treatment of fractures of the shaft of the fibula we usually employ a fracture-box for a week, and, when the swelling has subsided, apply a plaster of Paris bandage, which fixes the ankle and the knee-joint; if little displacement is present, the knee need not be fixed.

Fracture of the Lower End of the Fibula.—This is the most common fracture of the fibula: it is usually produced by indirect force, as by falls, and by twists of the foot causing extreme abduction or adduction, and is apt to lead to great deformity and subsequent disability. It is often described as Pott's fracture, which consists in a fracture occurring in the lower fifth of the fibula, with a laceration of the internal lateral ligament of the ankle-joint, and is usually accompanied by marked eversion of the foot. (Fig. 422.) With the fracture of the lower fifth of the fibula there may be associated a fracture of the inner edge of the tibia, as well as of the internal malleolus.

Symptoms.—The deformity is very characteristic, consisting in an outward displacement of the foot and a marked prominence of the internal malleolus; the ankle-joint appears to be markedly widened, and there may be more or less displacement of the astragalus. (Fig. 423.) The widening of the ankle results from separation of the malleoli, and occasionally from the astragalus being driven upward between the tibia and the fibula.

Fig. 422.



Fracture of the lower fifth of the fibula, Pott's fracture. (Agnew.)

Fig. 423.

Pott's fracture with marked deformity.

Treatment.—The most important point in the treatment of this fracture is to correct the displacement and prevent its recurrence. The fragments may be reduced by grasping the leg firmly with one hand and the foot with the other and drawing

the foot forward, pressing it inward at the same time until the astragalus is felt to press against the internal malleolus. After the deformity is corrected, the foot should be placed in a fracture-box padded with a pillow, a compress being placed above the internal malleolus and another just below the external malleolus, and when the sides of the box are brought up the foot will be slightly inverted. This dressing we usually employ for a week or ten days, if it satisfactorily corrects the deformity, and at the end of this time a plaster of Paris bandage is applied while the foot is held in its corrected position. The plaster of Paris bandage may be applied as a primary dressing. The Dupuytren splint, which was formerly employed in the treatment of this fracture, we have found usually to cause the patient much pain, and, although it corrects the deformity, its use is not satisfactory.

The dressings in fractures of the fibula are usually retained for about four weeks; after this time the patient should be allowed to get about on crutches. At the end of six weeks he may with safety place his weight upon the limb. It is extremely rare to have non-union occur in the fibula unless it is associated with non-union in the tibia at the same time.

Fracture of the External Malleolus.—This fracture is usually the result of sudden and forcible adduction of the foot, by which the astragalus is forced outward. It is diagnosed by the presence of pain, mobility, and crepitus, and is usually accompanied by marked swelling upon the outer surface of the ankle-joint.

Treatment.—The most satisfactory treatment in fracture of the external malleolus consists in the application of the plaster of Paris dressing, which should include the foot and the leg, and is retained for about four weeks.

FRACTURES OF THE BONES OF THE FOOT.

Simple fractures of the bones of the foot are not common. Falls from a distance, when the patient alights on his feet, are more apt to be followed by fracture of the bones of the leg than by fracture of the foot. Fractures of the bones of the foot may involve the tarsus, the metatarsus, or the phalanges.

Fracture of the Astragalus.—Fracture of this bone is rare; it usually results from falls, the weight of the body striking upon one foot.

Symptoms.—If there is no marked displacement of the fragments, the diagnosis is extremely difficult. The strong ligamentous attachments of the bone usually prevent much displacement. The diagnosis is made by the presence of persistent pain, inability to bear pressure on the foot, and rapid swelling, and by eliciting crepitus by flexing, extending, abducting, or adducting the foot. Where there is marked deformity the diagnosis is not difficult.

Treatment.—If there is displacement of the fragments in this fracture, the leg should be flexed upon the thigh, and deformity should be reduced by extension, counter-extension, and manipulation, the foot being subsequently fixed in an extended position at a right angle to the leg.

We had recently under our care a woman who had suffered from a fracture of the astragalus by a fall from a step-ladder, the weight of her body striking

upon one foot. In this case there was a very marked projection of a fragment of the astragalus upon the anterior surface of the foot below the ankle, which was reduced by pressure under anæsthesia.

There is usually marked swelling following this fracture, so that the application of an immovable dressing is not desirable for a week or ten days; we therefore prefer to apply as a primary dressing in these cases a well-padded moulded binders' board splint, which is retained for a week or ten days, a plaster of Paris dressing being then applied and retained for five or six weeks. More or less impairment in the motion of the ankle-joint is apt to result from this fracture, and the surgeon should be careful that the foot is kept as nearly as possible at a right angle to the leg, for in this position the foot will be most useful if ankylosis should occur.

Compound fractures of the astragalus are very serious injuries, and generally demand excision or amputation. (Fig. 424.)

Fracture of the Os Calcis.—This fracture usually results from falls upon the foot or from force directly applied to the plantar surface of the

Fig. 424.

Compound fracture of the astragalus. (After Miller.)

Fig. 425.

Comminuted fracture of the os calcis. (Agnew.)

foot. Fractures of the posterior portion of the os calcis also occasionally result from violent muscular contraction. (Fig. 425.)

Symptoms.—The symptoms presented by this fracture depend somewhat upon the position in which the bone is broken: if the posterior portion is separated, it may be displaced upward by the tendo Achillis through the action of the gastrocnemius and soleus muscles. If the subastragaloid portion is fractured, there is not apt to be much displacement, but there may be marked swelling and broadening of the sole of the foot.

Treatment.—In cases of separation of the posterior portion of the os calcis the deformity can best be reduced if the leg is flexed upon the thigh and the foot is fully extended. When the fragment has been brought into its natural position a well-padded curved splint may be applied to the anterior surface of the foot and leg, or a plaster of Paris dressing may be applied, holding the foot and leg in this position. In cases of subastragaloid fracture where there is marked deformity it may be treated in a fracture-box or by the application of a plaster of Paris bandage, the foot being fixed at a right angle to the bones of the leg. The time required for union in fractures

of the calcaneum is from six to eight weeks, and more or less swelling and stiffness about the ankle often persist for some time.

Fracture of the Metatarsal Bones.—Fractures of these bones usually result from direct crushing force, and are very apt to be compound. The first and fifth bones are those most frequently broken.

Treatment.—The treatment of these fractures consists in the application of a moulded splint of binders' board to the sole of the foot and the lower part of the leg, which fixes the motion of the ankle-joint, and may require the addition of a compress over the seat of fracture if there is a tendency to anterior displacement of the fragments, or they may be treated by the application of a plaster of Paris bandage. Union in fracture of the metatarsal bones is usually firm enough at the end of four weeks to permit of the removal of the dressings.

Fractures of the Phalanges of the Toes.—Simple fractures of the phalanges of the toes are comparatively rare injuries, for, as fractures of these bones generally result from crushing force, they are usually compound.

Treatment.—The fragments may be fixed by the application of a moulded binders' board splint which surrounds the injured toe and extends some distance back upon the plantar surface of the foot, so as to fix the motion of the metatarso-phalangeal joint. A light wooden splint may also be applied in the same manner. Union is usually firm at the end of three weeks.

Compound Fractures of the Bones of the Foot.—These fractures are much more common than simple fractures of the bones of the foot, and usually result from crushing force applied to the foot. The damage to the blood-vessels and soft parts is often so extensive that primary amputation is indicated. In cases, however, of compound fracture of the astragalus or calcaneum or other tarsal bones in which the soft parts are not extensively injured, it is often possible to save the foot. If there is marked comminution of the fragments it is wise to resort to primary excision of the fractured bone. Of course the greatest care should be observed to sterilize the wound and the surrounding parts and to prevent its subsequent infection. Very satisfactory results have followed excision of the astragalus, as well as of the calcaneum, in compound fractures of these bones. We had under our care recently a patient who had sustained a compound fracture of the astragalus in whom an excision of the comminuted astragalus was followed by a movable ankle-joint with little deformity. In a case of compound comminuted fracture of the calcaneum we removed the calcaneum entirely, and sutured the tendo Achillis, which had been torn away from the calcaneum, to the plantar fascia, the patient recovering with a useful foot.

In extensive compound fractures of the tarsal bones it may be considered a safe rule of practice to excise the injured bones, as by so doing free drainage is secured and the risk of tension is diminished. Compound fractures of the metatarsal bones and phalanges of the toes are treated by sterilization of the wound and fixation of the parts until union has been secured.

Sprain Fracture.—Under this name Callender describes an injury consisting in a separation of a tendon or ligament from its insertion into

a bone, accompanied with a detachment of a thin shell of bone. This injury is most apt to occur about the wrist-, knee-, or ankle-joint, and is probably the lesion which is present in many sprains about these joints in which recovery and restoration of the function of the part are very slow.

The *treatment* of sprain fractures consists in the immobilization of the part by the use of splints or by the plaster of Paris dressing. The time required for union is about the same as that required in cases of fracture.

COMPOUND FRACTURES.

Compound fractures may be produced in two ways—that is, from without or from within. In the former variety of compound fracture the force which causes the fracture lacerates the skin and tissue covering the bone at the seat of fracture, while in the latter variety the communication of the fractured bone with the air is caused by the ends of the bone being driven through the soft parts and skin. Therefore compound fractures produced from without are usually more serious injuries than those produced from within, for in the former there is apt to be a larger wound, and one in which the soft parts are more or less lacerated and contused, with a consequent diminution of their vitality; while in the latter—that is, those produced by the fractured ends of the bone—the wound is usually small, and unless there has been damage to important blood-vessels or nerves or subsequent infection of the wound, the injury is not so serious. Formerly compound fractures were among the most serious injuries that came under the care of the surgeon, and the mortality following them was very great, many patients dying of infective processes, such as pyæmia, septicæmia, erysipelas, gangrene, or tetanus, or from exhaustion following profuse suppuration; it was usual for extensive necrosis to occur in the fractured bone, which often left the limb useless, so that amputation subsequently became necessary. In view of these facts, it was the practice to resort freely to amputation in the treatment of compound fractures involving the extremities. Few compound fractures are now subjected to amputation, for we recognize the fact that if the wound can be rendered aseptic and kept in this condition there is little greater risk to the patient in this variety of fracture than in a corresponding simple fracture.

Treatment.—The early treatment of a compound fracture should be directed to the prevention of infection of the wound. When a compound fracture occurs at a distance from the place where the subsequent treatment of the case is to take place, the wound should be irrigated with an antiseptic solution, if possible, or, if this cannot be obtained, with boiled water or pure water, and covered with towels or cloths wrung out of boiled or pure water. If these precautions are taken, a compound fracture may be kept aseptic for some hours, until a more elaborate dressing is applied. If the wound is small and the skin is clean, and a scab of blood has formed over it, the wound should not be irrigated. In dressing compound fractures the greatest care should be observed in all the details to prevent infection of the wound, for the fate of the limb or of the patient often depends upon the care which is exercised in this respect.

Dressing of Compound Fractures.—The skin surrounding the wound which communicates with the fracture should be first rubbed over with spirit of turpentine and then thoroughly washed with Castile soap and water, the surrounding skin and the wound being irrigated with an antiseptic solution, 1 to 2000 bichloride solution, or with sterilized water or normal salt solution. Any foreign bodies which are in the wound should be removed with forceps or washed out; tissue which has foreign matter, such as grease, sand, or dirt, ground into it, should be gently cleaned with a gauze pad or curette; loose fragments of bone should be removed, fragments having periosteal attachments being allowed to remain. The question of the primary fixation of the fragments should always be considered in the case of compound fractures. We are inclined to think that one reason for the satisfactory results following compound fractures at the present day is the more general use of primary fixation of the fragments. This may be accomplished by drilling the fragments and suturing them together by heavy silver or kangaroo tendon sutures, or by silver splints and screws, or by ferrules of bone, as suggested and practised by Senn. After fixation of the fragments, drainage should be introduced and the external wound closed with sutures, unless there has been much laceration of the tissues, in which case it is better to introduce no sutures. If there is any question of the escape of discharges, sutures should not be used, the wound being treated as an open one. The wound and surrounding parts should next be covered with a copious antiseptic or sterilized gauze dressing, additional fixation of the parts being made by the application of splints appropriate for the special fracture, or by the use of a plaster of Paris dressing, which may be fenestrated. In compound fractures of the bones of the extremities, after dressing the wound we usually apply moulded splints of binders' board for a few days, which can easily be removed to dress it if necessary, and if it is evident that the wound is running an aseptic course we discard these and apply a plaster of Paris dressing. If in a case of compound fracture the wound has been infected before it comes under the care of the surgeon, and if in spite of his efforts suppuration occurs, frequent dressing of the fracture may be necessary, in which case some form of movable splints will be found very satisfactory. The time required for firm union in compound fracture is considerably longer than in simple fracture, from two to three months often being required.

Amputation or Excision in Compound Fractures.—Modern methods of wound treatment have made it possible to save many compound fractures which would otherwise be subjected to amputation or excision. The surgeon can in many cases now give the patient the benefit of the doubt without subjecting him to additional risks. In doubtful cases the wound should be carefully sterilized and protected from infection, and if in a few days it is evident that the parts are injured beyond the power of repair, amputation or excision may be resorted to with as fair a prospect of success as if performed as a primary operation. In many compound fractures with extensive destruction of the bones, muscles, vessels, and nerves, such as is produced in railway and machinery accidents, primary amputation offers the patient the best chance of recovery. In compound fractures involving

the joints, in which an operation is indicated, if the vessels and nerves are uninjured, excision should be preferred to amputation.

GUNSHOT FRACTURES.

These constitute a very serious class of compound fractures, which may be produced by a small shot at close range, pistol- or rifle-balls, round shot, or fragments of shells. They are not only serious injuries as regards the damage to the bone itself, which may be extensively comminuted or fissured (Fig. 426), but they are often complicated by injuries of important blood-vessels or nerves. The modern rifle-ball, which is nickel-covered, at certain ranges produces marked explosive effects, while at other ranges it has great penetrating power, so that both extensive comminution and penetration of bone may result. The gunshot fractures seen in civil practice usually result from small shot, pistol-balls, and rifle-balls, and, as a rule, the damage to the bone by these missiles is not so extensive as that produced by the modern military ball. The damage to the bone depends upon the size, shape, composition, and velocity of the ball.

Fig. 426.

Gunshot fracture of the upper extremity of the femur. (Army Medical Museum.)

Gunshot fractures produced by small shot at short range, and by fragments of stone or wood in blasting accidents, are usually very serious injuries, by reason of the extensive damage inflicted upon the soft parts. It is now possible to save many cases of gunshot fractures which would formerly have been subjected to resection and amputation.

Treatment.—The treatment of gunshot fracture does not differ materially from that of compound fractures received in other ways, and, as in the latter class of injuries, depends upon the amount of injury done to the bone and surrounding soft parts. It is now recognized that the removal of the ball in cases of gunshot fractures is not the most important part of the treatment, and that extensive exploration of the wound for this purpose is unnecessary, but that antiseptic irrigation of the wound and sterilization of the surrounding parts are much more important procedures. In a gunshot fracture in which the bone has been perforated or divided without comminution, the wound or wounds should be irrigated with bichloride solution or sterilized water, the skin surrounding the wound sterilized, a drainage-tube or strip of gauze introduced, and an antiseptic or sterilized gauze dressing afterwards applied. If the ball can be located and removed without extensive incisions or manipulations, this should be done. If loose fragments of bone are present in the wound they should be removed, but partially detached fragments should be allowed to remain. Primary fixation of the fragments may be accomplished by the use of heavy wire sutures when the bone is superficial, and their introduction does not entail an extensive dissection of the soft parts. Drainage should always be employed in cases where there has been much comminution of the bone or laceration of

the soft parts. Immobilization of the fragments by the use of splints after the wound has been dressed is a very essential part of the successful treatment of these cases, the ordinary splints and dressings employed in similar fractures from other causes being used.

Amputation in gunshot fracture may be required in the primary stage when there is great comminution of the bone with laceration of important vessels, or it may be necessary to resort to this procedure later if the wound becomes infected, and osteomyelitis, gangrene, or necrosis occurs. In gunshot fractures of the long bones, primary or secondary resection of the bones, with wiring of the fragments, may sometimes be substituted for amputation.

UNUNITED FRACTURE, OR PSEUDARTHROSIS.

Delayed Union.—A fracture in which the bones are not firmly united and mobility is present after the lapse of the time when it is usual to have firm union, is described as one of delayed union. Delayed union is not uncommon after fractures, and results from constitutional causes, such as impaired vitality, from the presence of various diseases, and from shock; also from local causes, such as improper dressing and insufficient fixation of the fragments at the seat of fracture. The fact that union is delayed in a fracture does not imply that it will ultimately fail to unite. We have often seen cases in which there was comparatively little union at the end of six or eight weeks, yet in which after a few months, by improvement in the patient's constitutional condition and the use of more efficient fixation apparatus, firm union was finally obtained. We consider that it is unwise to desist from treatment in cases of delayed union for at least six months; after this time, if no union is present, the case may be considered one of ununited fracture.

Treatment.—The treatment of delayed union consists in improvement of the patient's constitutional condition and the employment of dressings which will produce the most perfect fixation of the fragments at the seat of fracture. *Friction* of the ends of the bone until some reaction ensues, with or without an anæsthetic, and subsequent fixation of the fragments by a plaster dressing, is most efficient. Fixation of the joints adjacent to the fracture should be practised. Plaster of Paris dressings, changed every two or three weeks, we have also found satisfactory in these cases. Bier's method of elastic constriction has been employed with good results.

Ununited Fracture.—This is not a frequent complication of fractures. Hamilton estimates that about one case occurs in five hundred fractures. If union in a fracture has failed to take place in six months, the case may be considered one of ununited fracture.

Causes.—Ununited fractures may result from constitutional or local causes. Among the constitutional causes which seem to predispose to non-union are fevers, hemorrhage, shock, gestation, and lactation. Advanced age, syphilis, and paralysis seem to have little effect in causing non-union in fractures. Non-union is most frequently observed in the femur, humerus, tibia, and ulna. (Figs. 427 and 428.)

Local Causes.—These include imperfect coaptation of the fragments, such as marked overlapping, with the interposition of muscular tissue or

fascia, tendon, or nerve, or a fragment of devitalized bone, between the fragments, imperfect fixation of the fragments, which permits of free motion, and too tight dressings, interfering with the vascular supply of the bone necessary for its repair. We are, however, inclined to think that the most frequent cause of non-union in fractures is the interposition of a shred of muscular tissue or fascia between the fragments, and that improper dressing, allowing considerable motion, is not a frequent cause of non-union, rather tending to produce an excessive amount of callus at the seat of injury.

FIG. 427.

Ununited fracture of the bones of the right leg. (Dr. Robert Abbe.)

FIG. 428.

Skiagraph of ununited fracture of the tibia. (Dr. J. M. Stern.)

In the majority of cases of ununited fracture upon which we have operated we have found muscular tissue, fascia, or tendons between the fragments. When one considers the violence done to the bone as well as to the surrounding tissues, it is not remarkable that tissues should be interposed between the ends of the fragments, and it is surprising that non-union after fracture is not more common. In view of the greater safety with which operations can now be undertaken, we think the time is not far distant when it will be considered the proper treatment in simple fractures with great deformity, or in those in which it is difficult to retain the parts in position after reduction, to cut down upon the fragments and secure primary fixation by the use of sutures, as by such a procedure accurate apposition of the fragments may be secured and retained, and the risk of non-union guarded against by preventing the interposition of tissues between the fractured ends of the bone.

Varieties of Ununited Fractures.—Various conditions may exist in the bone at the seat of fracture as the result of non-union. (1) The ends of the bone, being subjected to more or less motion upon each other, may become rounded and covered with fibrous tissue. (Fig. 429.) This variety of non-union often results where there has been a considerable loss of substance in the bone, and is followed by marked disability from the great mobility at the seat of fracture. (2) The ends of the fragments may be united to each other by a more or less firm band of fibrous tissue, which

allows of a considerable amount of mobility between the ends of the bone. (Fig. 430.) This is by far the most common variety of ununited fracture.

Pseudarthrosis.—Another variety of ununited fracture which is occasionally seen is that in which a false joint is formed at the seat of fracture. The new joint is of the ball-and-socket type, one fragment being rounded and the other hollowed out. The surfaces of the bone are smooth and covered by fibrous tissue or fibro-cartilage, and a more or less completely

FIG. 429.

Ununited fracture with rounding of the ends of the bone. (After Agnew.)

FIG. 430.

Fibrous union between the ends of the fragments. (After Agnew.)

FIG. 431.

False joint in ununited fracture. (After Agnew.)

developed capsule is formed from the surrounding soft parts, lined with endothelium, which secretes a synovial fluid. This variety of ununited fracture probably results from prolonged motion in cases of transverse fracture in which close fibrous union was originally present. (Fig. 431.)

Treatment.—It should be remembered that non-union in the bones of the lower extremity, even if permitting only a slight degree of motion, is followed by more disability than results from non-union in the bones of the upper extremity. A patient with a moderate amount of motion in an ununited fracture of the shaft of the humerus, radius, or ulna will often have a fairly useful arm, while a corresponding amount of motion in the shaft of the femur or tibia will interfere very markedly with locomotion.

Various methods of treatment have been recommended and practised for the relief of ununited fracture, such as friction of the ends of the bone, drill-

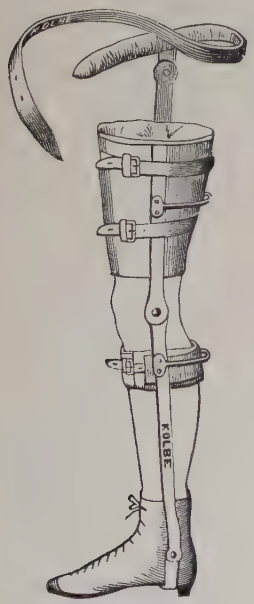
ing and subsequent fixation, the use of mechanical apparatus, and excision of the ends of the bone followed by fixation with sutures or metal splints.

Friction.—This method may be employed in ununited fractures, and is often followed by good results, but should be reserved for comparatively recent cases.

Drilling.—Drilling the ends of the fragments through a small puncture has been practised with success in many cases. If such treatment is adopted, care should be taken that the skin surrounding the seat of puncture is thoroughly sterilized, as well as the drill with which the ends of the bone are perforated. The ends of the bone may also be freshened with an osteotome introduced through a small wound. This procedure we recently practised with a satisfactory result in a child who suffered from an ununited fracture of the femur. Fixation after either of these operations should be secured by splints or by the plaster of Paris bandage.

Mechanical Apparatus.—In cases where an operation is not to be recommended, either from the risk that it entails or from the fact that the patient is in a debilitated condition or refuses operative treatment, mechanical apparatus may be employed with advantage. In ununited fractures of the humerus a moulded leather splint or a splint attached to a metal brace will often permit the patient very good use of the arm. In ununited fractures of the tibia and fibula a brace may be worn with comfort, and union may follow. In ununited fractures of the femur, where operative treatment is always attended with danger from shock and hemorrhage, the application of a brace, as is seen in Fig. 432, will often permit the patient to have good use of the part. In some cases after wearing such an apparatus for a time union has finally taken place at the seat of fracture.

Fig. 432.

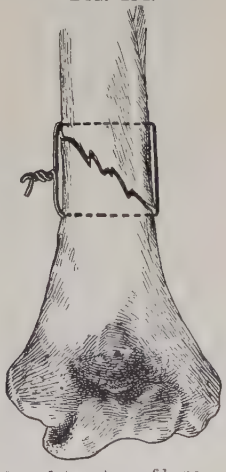


Apparatus for ununited fracture of the femur.

Fig. 433.

Partial suture of bone.

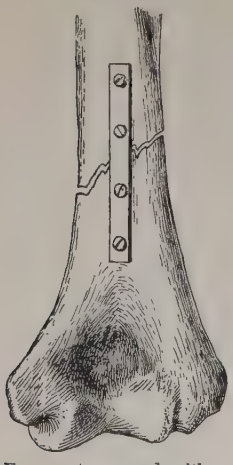
Fig. 434.



Complete suture of bone.

Excision.—The most radical operation, and the one most likely to be followed by a satisfactory result in ununited fractures, is excision of the ends of the bone, with fixation of the fragments by metallic sutures, screws, metal plates, ivory pegs, or a bone ferrule. In performing this operation the ends of the bone are exposed by an incision, and a section is sawn off each end so as to get a good bone surface. In some cases of oblique fracture the ends may be sawn so as to make a mortise of the bone. The ends being drilled, they are fixed with heavy silver wire or kangaroo tendon sutures, the sutures including a portion or the whole thickness of the bone (Figs. 433 and 434), by silver plates secured by silver screws (Fig. 435), or by a screw (Fig. 436), or by a bone ferrule (Fig. 437): the latter is the most difficult to apply. The wound is then closed, and the limb is put up in a plaster of Paris bandage. The

Fig. 435.

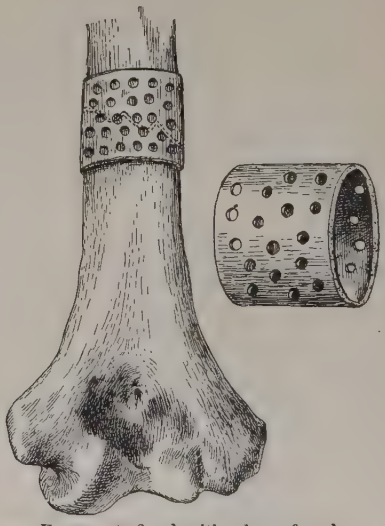


Fragments secured with a silver splint and screws.

Fig. 436.

Fragments secured with a screw.

Fig. 437.



Fragments fixed with a bone ferrule.

greatest care should be taken to keep the wound aseptic, for the success of the operation depends largely upon avoiding suppuration. The wires or plates, if suppuration does not occur, may remain permanently in the tissues.

In cases of non-union of one of two parallel bones it may be necessary to resect a portion of the sound bone in order to coaptate satisfactorily the ends of the bone in which union has not occurred. In such cases bone-grafting—a piece of fresh bone from a recently killed animal being fastened by sutures or ivory pegs between the freshened ends of the bone, or the space between the freshened ends of the bone being filled in with bone chips—has been practised with success. These procedures, however, often fail, and a plastic operation is required. This consists in transplanting a portion of one bone into the other, or one bone may be sutured to the other, as has been done with success in cases where there was a marked loss of substance in the tibia, the fibula being divided and sutured to the tibia. The dressings should be retained for several months, and the patient restricted in the use of the part for some months afterwards.

Deformed Union.—This complication after fractures may result from imperfect reduction at the time of the accident, or from secondary displacement caused by the use of improper dressings, allowing motion at the seat of fracture. (Fig. 438.) Faulty or deformed union cannot in all cases be credited to the surgeon, for where there is great swelling it may be impossible with the utmost care to recognize the displacement of the fragments, and in some cases the bones are crushed or comminuted so extensively that it is impossible to restore their shape, or the obliquity or the irregular line of the fracture may prevent the restoration of the shape of the bone. In fractures complicated with flesh wounds, burns, or scalds, it may be impossible to apply any retentive apparatus; the patient also may remove or interfere with the dressings and splints, or suffer from mania or delirium tremens, which conditions may prevent coaptation of the fragments or lead to secondary displacement and result in deformed union.

Treatment.—The treatment of deformed union, if it interferes with the usefulness of the part, consists in correcting the deformity by refracturing the bone if possible. If the fracture is not solidly united, it may often be corrected by bending the bone before the callus has become firm. After the correction of the deformity the part should be fixed by the application of a firm dressing, such as plaster of Paris. In some cases where the deformity is marked and union at the seat of fracture is firm, a linear or cuneiform osteotomy may be employed with advantage. In a case of deformity after fracture of the femur (Fig. 439) we resorted to osteotomy to correct the deformity, and the satisfactory result obtained is shown in Fig. 440.

Fig. 438.

Deformed union after fracture of the femur. (Agnew.)

Fig. 439.

Fig. 440.

Deformity after fracture of the femur corrected by osteotomy.

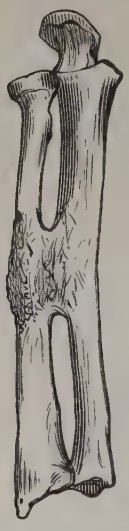
Affections of Callus.—Callus thrown out in the repair of fractures may undergo various changes as the result either of local or of constitutional causes.

Exuberant Callus.—This formation is often observed after a comminuted fracture, or one in which there is great overlapping: it is especially noticed in long bones in fractures near the joints, and is frequently observed in fractures of the femur near the hip-joint. The mass of callus may be so extensive as to project into the surrounding tissues and cause pressure upon contiguous nerves. (Fig. 441.) In the case of the ulna and the radius, a bridge of bone may unite them, destroying the motions of pronation and supination. (Fig. 442.)

Fig. 441.

Excessive callus in fracture of the femur. (Agnew.)

Fig. 442.



Callus uniting the ulna and the radius. (Agnew.)

Softening and Absorption of Callus.—Callus may undergo absorption after fracture as the result of premature motion or of constitutional causes. A patient with a fracture firmly united at the end of six or eight weeks, as the result of a depressed constitutional condition, produced by typhoid fever or other adynamic disease, may have the callus soften and motion again appear at the seat of fracture. This is not uncommon after osteotomy for rachitic deformity if the disease is still active. In such cases, however, if the patient recovers from the disease, it is not unusual for the union to become firm again at the seat of fracture.

Consecutive Shortening.—This usually results after fracture from the patient's beginning to use the limb before the callus is firm. It is most frequently observed in fractures of the lower extremity. Here the shortening is probably due to condensation of the not yet firm callus. The surgeon should bear in mind the possibility of consecutive shortening, and discourage the use of a fractured limb until it is quite clear that sufficient time has elapsed for the callus to become firmly consolidated.

Fracture of Callus.—This results from violence applied to a fractured bone before the callus has become thoroughly consolidated, and may occur from the application of only a moderate amount of force. After a bone has firmly united it is unusual to have a fracture occur at the seat of fracture, even upon the application of great force, it being apt to give way at another point. We had under our care a short time ago a man who, after the removal of the splint in case of fracture of the arm, suffered from two fractures of the callus at intervals of a few weeks from slight falls. It is often observed in fractures of the lower extremities after removal of the splints and dressings, when the patient receives a fall from the unaccustomed use

of crutches; we have seen a number of refractures of the femur produced in this manner. The repair of fracture of callus is usually very prompt, less time being required than in the case of primary fractures.

Tumors of Callus.—New growths developing in the callus at the seat of fracture are rare, except in subjects who are suffering from cancer in other parts of the body; we have seen a woman suffering from cancer of the breast, who sustained a fracture of the femur, develop a large carcinomatous mass in the callus at the seat of fracture. Cases of enchondroma and sarcoma have, however, been reported as developing in callus after fracture when there was no evidence of the disease in other parts of the body. Separations or injuries of the epiphyses in young subjects seem more likely to be followed by the development of sarcomatous growths than fractures.

Complications after Fracture.—Rupture of an Artery.—This may result from stretching or tearing of the vessel or laceration of its coats by the fragments of bone. As the result of this accident a traumatic aneurism forms, which can be recognized by the swelling, change in the color of the limb, loss of pulsation in the injured artery, expansile pulsation and bruit, or thrill. It is wise, if the aneurism is not increasing in size, to postpone its treatment until consolidation has occurred at the seat of fracture.

Embolism and Thrombosis.—A thrombus may occur from injury to the veins, and an embolus may be detached and be swept into the heart or the pulmonary artery, causing a fatal termination. A thrombus may result from contusion or bruising of an artery at the seat of fracture and lead to gangrene. Fat embolism is a rare complication, which is considered in another part of this work.

Delirium Tremens.—This is not an unusual complication of fractures in subjects addicted to the use of alcohol, and may develop soon after the occurrence of the injury or some weeks afterwards. Its development is usually preceded by agitation and insomnia.

Gangrene.—This is an occasional complication after fracture, and occurs from injury of the soft parts at the time of fracture or subsequently from compression of important vessels by the fragments of bone. It may involve a portion of the limb only, or the whole limb up to the seat of fracture. Traumatic spreading gangrene is an occasional complication of compound fractures.

Tetanus, *septicæmia*, and *pyæmia* are complications of compound fractures which are rarely seen when aseptic methods of treatment have been carefully practised.

Paralysis.—This may occur as a direct result of injury to an important nerve at the time of fracture, or may develop later from the pressure of callus upon a nerve. Wrist-drop is sometimes observed after fracture of the shaft of the humerus from injury of or pressure upon the musculo-spiral nerve, and foot-drop is sometimes observed after fracture of the fibula or the external condyle of the femur, from the pressure of the callus upon the external popliteal nerve.

Ankylosis.—Ankylosis of joints is a later complication of fractures, and is apt to occur after fracture in the vicinity of joints, or one in which the line of fracture extends into the joint, producing malposition of the

articular surface of the bone. Ankylosis occurring from fracture near a joint is usually due to thickening of the tissues about the joint and from disuse of the joint, and is not apt to be permanent. On the other hand, when there is displacement of the articular surface of one of the bones making up the joint, the ankylosis is apt to be permanent. This is one of the most troublesome complications in fractures near or involving the elbow- or knee-joint.

In cases of ankylosis of a joint following fracture, massage and passive motion will do much to overcome the stiffness at the joint and restore its function, being of course followed by better results in case of ankylosis from disuse and periarticular thickening than where there has been absolute involvement of the joint in the fracture.

Muscular Wasting.—This condition may result from disuse of the muscles consequent upon the prolonged use of fixation apparatus, or from injury of or pressure upon nerves as the result of the fracture. In the former case, when the splints are removed and union at the seat of fracture is firm, the use of massage as well as exercise of the affected muscles will soon restore their function. Muscular wasting following nerve injury or pressure should be treated by galvanism; if this fails to be followed by benefit it may be necessary to expose the nerve, and if it is divided to unite it by sutures; excision of a degenerated portion of the nerve, or the removal of callus pressing upon it, may also be required.

Restoration of Function after Fracture.—In cases of fracture the union of the bone is usually firm in from six to eight weeks, but the restoration of function in the injured part is sometimes delayed for many weeks or months, which is often due to a prolonged immobilization or failure to practise passive motion during the course of treatment. The part, after the removal of the splints and dressings, is painful, and swells upon being placed in a dependent position, from loss of tone in the blood-vessels, and there is also more or less stiffness of the joints and tendons. The restoration of function can best be hastened by massage and rubbing the skin with soap liniment, and by encouraging the patient to use the part carefully. The application of a flannel bandage, which possesses some elasticity, may be followed by good results in diminishing the amount of swelling. The swelling is most marked after fractures of the lower extremity, and patients should not allow the part to remain in a dependent position for too long a time, but should constantly change its position. Massage and passive motion are the two most valuable means of hastening the restoration of function after fractures.

DISEASES OF BONE.

PERIOSTITIS.

This consists in an inflammation of the periosteum, usually resulting from microbic infection, and may be classified as *Acute Suppurative*, *Chronic* or *Tubercular*, *Syphilitic*, and *Actinomycotic Periostitis*.

Acute Suppurative Periostitis.—This affection sometimes follows injuries and wounds of bone, and the disease if limited in extent and properly treated is not followed by extensive necrosis. In these cases the periosteum

becomes swollen and vascular and can be easily separated from the bone; swelling and pain occur early, and pus accumulates between the periosteum and the underlying bone; superficial necrosis of the compact layer of the bone may occur. The more common variety of suppurative or infective periostitis, sometimes described as osteoperiostitis, does not occur as a primary affection following injuries, but is secondary to osteomyelitis, and is often observed as part of an infective process following direct or indirect infection from pus microbes, or after scarlet fever, measles, or typhoid fever. It is characterized by marked constitutional disturbances and extensive necrosis of the bone, suppurative arthritis, and often pyæmia, and is a most serious affection. All forms of acute periostitis may, therefore, be considered to result from pyogenic infection; in certain cases the pyogenic organisms reach the periosteum by a direct wound, while in others, where the skin is unbroken, the organisms reach the infected district by way of the circulation. A contusion of the periosteum may be an important factor in localizing the infective inflammation at the point of injury.

Symptoms.—In suppurative or infective periostitis the region involved becomes swollen and painful; if the periosteal inflammation is a primary affection, the swelling and tenderness appear early, whereas if it is secondary to osteomyelitis the local pain and swelling appear later. The patient may have a chill or rigor, followed by marked elevation of temperature. The skin over the inflamed area becomes œdematous and red, and sooner or later fluctuation can be detected.

Treatment.—In suppurative periostitis prompt treatment is indicated, and consists in making a free incision, with full precautions as regards asepsis, through the tissues and periosteum, to permit the inflammatory exudations to escape. If this is done early the bone may be found little affected, and recovery may occur without necrosis, or with only the development of a superficial necrosis, a thin shell of bone finally separating before the wound closes. Usually as the result of free incision the pain and swelling, as well as the constitutional symptoms, disappear. If, however, the periostitis is secondary to osteomyelitis, simple incision of the periosteum is not followed by relief of the symptoms, and a more radical operation is required: the case should then be treated as one of osteomyelitis, which will be described later.

Chronic or Tubercular Periostitis.—This is comparatively rare as a primary affection, but is very common in connection with tuberculosis of the underlying bones, and is sometimes seen in the periosteum over the ends of the long bones, but is more frequent in the carpal and tarsal bones, the ribs, the vertebræ, the cranium, and the bones of the face. When it occurs as a primary affection, extensive destruction of the periosteum may occur, and the disease extends to the structures outside of the periosteum, and sooner or later tubercular abscess develops.

Symptoms.—Pain and tenderness are not marked, and the first symptom which attracts the patient's attention is the swelling. The patient often shows symptoms of failing health before the local condition becomes marked. Softening and breaking down of the inflamed tissues in tubercular periostitis occur earlier than in syphilitic periostitis, and pain is not so marked as in the latter affection.

Treatment.—As soon as the affection is recognized, the patient should be given those remedies which are known to possess antitubercular properties, such as cod-liver oil and iodide of iron, and also nutritious and easily assimilated food; he should be in the fresh air as much as possible, and should have a change of climate. The local condition may be treated by the injection of iodoform emulsion into the infected tissues, the injections being repeated, at intervals of a week, for some time, which may be followed by the arrest of the tubercular process. If a tubercular abscess has formed, it should be aspirated, and when the contents have been removed the cavity should be injected with iodoform emulsion. If, however, the abscess has ruptured and a sinus remains which discharges continually, or if the local condition fails to improve in spite of the iodoform injections, the parts should be freely exposed by incision, under rigid aseptic precautions, and the diseased tissues removed with a gouge or curette, and if the superficial layers of the bone are involved they should also be removed. The resulting wound should be loosely packed with iodoform gauze or with gauze saturated with iodoform emulsion; this dressing should be renewed at intervals. Treated in this way, the wound will often heal satisfactorily.

Syphilitic Periostitis.—This is one of the later manifestations of syphilitic infection, which may be seen in acquired syphilis or in hereditary syphilis. The most common seats of the periosteal inflammation are the shafts of the long bones; the anterior surface of the tibia is a favorite locality, as are the bones of the cranium. Two distinct pathological processes may occur in syphilitic periostitis: the granulation-tissue may be converted into osseous tissue, causing marked thickening and deformity of the underlying bone, or gummata may develop, which may soften so that fluctuation can be elicited. These softening gummata are often mistaken for abscesses and opened, and, if infection occurs, are apt to suppurate freely and be followed by more or less necrosis of the underlying bone.

Symptoms.—In syphilitic periostitis the pain is usually severe, and is worse at night, which is a characteristic symptom of this affection, and at the same time the patient may exhibit other symptoms of syphilitic infection. It is most likely to be confounded with tubercular periostitis, but the pain in the latter affection is usually wanting, and other evidences of syphilis may be present which will aid in making the diagnosis. In obscure cases the patient should be put upon antisyphilitic treatment and its effect noted.

Treatment.—The treatment consists in the administration of iodide of potassium in full doses, or of iodide of mercury or corrosive sublimate in small doses combined with the iodide of potassium, and in the gummatous variety of the affection the results are most marked, the pain and thickening usually soon disappearing. In the variety, however, in which hypertrophy and deformity of bone have occurred, although the pain may be relieved and the progress of the disease arrested, the deformity and thickening do not seem to be much affected by the use of internal treatment. The local treatment consists in the application of equal parts of mercury and belladonna to the gummatous swellings, which, combined with the constitutional treatment before mentioned, often seems to hasten their

absorption. In cases where marked osseous changes have occurred, and where in spite of constitutional and local treatment pain is a prominent symptom, we have often seen great relief follow a free incision of the thickened bone by a Hey's saw; of course great care should be observed to prevent infection of the wound.

If gummata have broken down and become infected, they should be curetted and dressed with iodoform gauze until cicatrization has occurred.

Actinomycotic Periostitis.—This affection is observed in the jaws, and results from the extension of the actinomycotic process from the alveolus; marked swelling of the jaw occurs, but pain is not a prominent symptom; abscess may occur if pyogenic infection takes place in the affected tissue.

Treatment.—The medicinal treatment consists in the administration of iodide of potassium, which seems to have some control over this disease. The operative treatment, however, is more to be relied upon, and consists in exposure of the infected tissues by incision and their removal by the knife, the curette, or the actual cautery.

OSTEOMYELITIS.

Osteomyelitis is an inflammation of the medullary canal and the tissues lining the cancellous portion of bone, and may present itself as *simple acute*, *acute infective*, and *chronic osteomyelitis*. Although these clinical varieties of osteomyelitis are recognized, it is probable that they all depend upon the action of pyogenic organisms, and in the less serious varieties of the affection the virulence and the extent of the bone affection are controlled by the individual resistance of the tissues to the infection.

Simple Acute Osteomyelitis.—This affection occurs after some definite injury to bone, such as fractures, simple or compound, gunshot wounds, or amputation, and is characterized by inflammation of the medulla of the bone, in which the vessels are congested and dilated. Effusion and exudation take place, as well as increased cell-growth. The inflammatory exudation in the medulla may undergo resolution, organization, or suppuration. If developed to a slight extent, the constitutional disturbance may not be marked, and resolution or organization may occur with comparatively little destruction of bone-tissue, as is seen in the repair of fractures and the closing of the medullary canal after amputations. If the extent of injury is greater, and inflammation is more widely and intensely developed, the vitality of a limited extent of bone may be affected, suppuration may occur, and a circumscribed necrosis of the bone result. In view of the limited extent of the bone-destruction and the less serious constitutional symptoms which are manifested, many observers are disposed to consider that this form of osteomyelitis does not result from infective organisms; but there is reason to believe that any case of osteomyelitis in which suppuration occurs or necrosis is present is due to infective organisms introduced through a wound or by the circulation.

Treatment.—In simple acute osteomyelitis following injuries of bone it is often difficult to recognize the condition at the outset, as it is generally limited in extent and accompanied by little constitutional disturbance. If

the condition is developed after amputation or compound fracture, the most important factor in treatment is to secure free drainage and see that further infection of the wound is prevented.

Acute Infective Osteomyelitis.—This is essentially a septic inflammation of the medulla of bone, which is caused by infection by pyogenic organisms, resulting in suppuration and necrosis. It is accompanied by marked constitutional disturbance, and may lead to a fatal termination from septicæmia or pyæmia, or from exhaustion following the profuse discharge. Clinically two varieties of infective osteomyelitis are recognized: traumatic osteomyelitis and the so-called spontaneous osteomyelitis.

Traumatic Osteomyelitis.—This variety of osteomyelitis was formerly very common, and was recognized as one of the most serious complications which followed compound fractures and operations upon bone. In compound or gunshot fractures, or after amputation or resection of bone, if the wound is infected at the time of operation or afterwards, inflammation occurs in the medullary canal, followed by suppuration and destruction of a limited portion or the whole of the bone; the patient at the same time may develop symptoms of septicæmia or pyæmia. The medullary canal being exposed, the infection may occur primarily or may result from organisms entering it from suppuration in the surrounding parts. When infection has once taken place it may involve only a limited amount of the bone, or may extend throughout the canal, and, the products of inflammation being confined within the bony walls and having no outlet, thrombosis and arrest of circulation take place, and necrosis results.

In osteomyelitis after amputation the medulla becomes inflamed, suppuration occurs, and, if the constitutional infection does not cause death, the bone becomes necrosed and a tubular sequestrum forms, which in time separates from the surrounding healthy bone.

At the same time that inflammatory changes are taking place in the bone, the patient exhibits more or less elevation of temperature and acceleration of the pulse, and in many cases develops septicæmia or pyæmia.

Treatment.—The *prophylactic* treatment consists in thorough sterilization of all wounds of bone and in the exercise of the greatest care to prevent wound-infection during and after operations upon bone. When osteomyelitis has developed in a compound fracture or an amputation, the bone should be exposed and the inflamed medullary canal opened and scraped or curetted and irrigated with a bichloride solution; after drainage by gauze or tubes has been established, the wound should be closed; if necrosed bone is present, it should be removed. Under this treatment the disease is generally arrested, and the constitutional symptoms rapidly disappear.

Spontaneous Osteomyelitis.—The so-called spontaneous osteomyelitis occurs without the presence of a wound of the bone, the infection being carried by pyogenic organisms which reach the medulla by the circulation. The disease generally affects the long bones, and is seen most frequently in children. It usually starts near the epiphyseal line, and often spreads rapidly, so that it soon involves the whole shaft of the bone. The bones most frequently affected are the femur, tibia, humerus, fibula, and radius. The portion of the bone at which there is the greatest blood-supply is usually the

point of infection, consequently the disease commonly begins at or near the epiphyses.

Causes.—Osteomyelitis may occur either as an acute or as a chronic affection, and in either variety of the disease the essential cause is the presence of one or more varieties of pyogenic organisms: the staphylococcus pyogenes aureus is the organism oftenest observed. Infection may occur by direct extension from a suppurating lesion by means of the lymph-vessels, but more frequently it results from pyogenic organisms which have found their way into the circulation from an infected wound, or through the respiratory or intestinal mucous membrane, and accumulate in the medullary tissue in the region of the epiphyses, this localization being probably due to the increased vascularity of the bone in these positions. Slight traumatisms in the region of the epiphyses of the long bones may predispose to the localization of the pyogenic organisms at these points. We are disposed to think that slight traumatisms of the extremities of the long bones are important in the localization and development of the disease. Kocher believes that the extravasation of blood following a traumatism plays an important *rôle* by acting as a culture medium for the growth of micro-organisms. In almost all the cases of osteomyelitis that have come under our observation there was a history of a sprain or twist which was followed by the development of the infective inflammation. We had under our care some time ago an anæmic, delicate child who had sustained a simple fracture of the lower end of the fibula, in whom several weeks afterwards there developed an osteomyelitis at the seat of fracture, followed by suppuration and necrosis of the bone. Experimentally osteomyelitis has been produced in animals suffering from fractures by the injection of septic materials into the circulation. It is a curious fact, however, that slight traumatisms, such as sprains and twists about the epiphyses, seem much more likely to be followed by osteomyelitis than serious injuries, such as extensive comminuted fractures. We often see patients suffering with one or more fractures who have at the same time a suppurating and presumably infected wound, and yet the development of osteomyelitis in these cases is a very rare occurrence.

Osteomyelitis not only results from infection by staphylococci and streptococci, but may be caused by certain specific organisms, such as those of typhoid fever, scarlet fever, measles, variola, and diphtheria; in such cases the infection is probably a mixed one. The not infrequent occurrence of osteomyelitis and necrosis of the jaw following measles and scarlet fever was so well recognized by the older surgeons that the name *exanthematous necrosis* was applied to this affection. Osteomyelitis and subsequent necrosis are also occasionally seen after typhoid fever, diphtheria, and small-pox. (Fig. 443.) Exposure to cold and sudden chilling of the body in children are considered by Senn to be frequent causes of osteomyelitis. Prolonged chilling of the surface of the body produces a sudden disturbance in the circulation of the medullary tissue of the bone, resulting in congestion, implantation, and localization of the pyogenic organisms which may be present in the circulation. Under such conditions the localization is apt to occur at the point of least resistance, the medullary tissue, and suppurative inflammation develops. In many cases of osteomyelitis the existence of a distinct suppu-

rating lesion, from which pyogenic organisms enter the circulation, can be clearly demonstrated.

Pathology.—The inflammation begins in the capillaries from implantation of micro-organisms, and suppuration results. The veins become thrombosed, micro-organisms entering them cause liquefaction of the coagulated blood, and pyæmia in certain cases results from fragments of infected thrombi being carried to distant organs. Thrombosis of the veins is also one of the immediate causes of necrosis. Pus may extend through the whole medullary canal and infiltrate the spongy tissue of the bone. The periosteum later becomes detached by the accumulation of pus between it and the bone, and at points may be destroyed by a phlegmonous inflammation; the pus finds its way into the surrounding structures, and the resulting abscess either opens spontaneously or is opened by the surgeon. A layer of bone is developed in time from the periosteum, which is known as the *involucrum*, and the whole or a portion of the devitalized shaft, known as a *sequestrum*, remains in its new bony sheath, usually communicating with the skin by one or more sinuses, which open into the involucrum, the openings being called *cloacæ*. The size of the sequestrum resulting varies with the intensity of the infection and the amount of venous thrombosis occurring. The whole shaft of a long bone may be destroyed from epiphysis to epiphysis (Fig. 444), or a limited portion of the shaft may become devitalized. If the staphylococcus or streptococcus infection is very virulent, there is first developed a localized leucocytosis, which is followed by the development of small or extensive abscesses, and, the products of inflammation being confined within the bony walls, arrest of the circulation occurs, so that necrosis results. In other cases the suppuration may be circumscribed and a chronic bone abscess results, which may remain latent for months or years, when the micro-organisms may again be aroused to activity by some exciting cause, producing an acute osteomyelitis. In certain cases the attack may be so mild that pus is not formed, and a fluid resembling synovia is poured out beneath the periosteum, which may undergo mucoid degeneration and be contained in a distinct cyst; this has been described as

Fig. 443.

Shaft of the tibia removed from a case of osteomyelitis following typhoid fever.

Fig. 444.

Necrosis of the shaft of the tibia from infective osteomyelitis.

albuminous osteomyelitis or *periosteal ganglion.* It is a rare affection, and one which can be definitely diagnosed only after an incision has been made.

Symptoms.—The disease is usually ushered in by a chill or rigor, which is followed by high fever, and the local symptoms of the affection may be accompanied by the development of a condition of profound septic intoxication, the patient passing into a typhoid state, with stupor and delirium.

Pain is an early and persistent symptom, is of a gnawing or boring character, and is usually located in the end of one of the long bones. It may not be distinctly limited to the area of bone involved, but may extend to the shaft of the bone and adjacent joints. It is usually more severe at night, increases with the elevation of temperature and also with the extent of the exudation, and very materially diminishes if perforation of the bone occurs and the inflammatory exudations escape into the surrounding tissues. In cases of multiple osteomyelitis pain may not be a prominent symptom.

Tenderness on pressure, which is probably due to secondary periostitis, is most marked as the disease approaches the surface of the bone, but is often present early in the disease before any swelling has made its appearance. Tenderness on pressure is both a valuable diagnostic sign and an important guide to the surgeon in determining the position at which the medulla should be exposed by operation.

Swelling.—From the fact that the primary inflammation is located in the interior of the bone, swelling is not marked until the periosteum and the connective tissue become involved. *Œdema* of the connective tissue from thrombo-phlebitis and enlargement of superficial veins may cause the earliest swelling at the seat of disease, but when the bone and the periosteum have been perforated and pus escapes into the connective tissue the swelling becomes marked, and fluctuation can be elicited.

Redness.—This is not present in the early stages of the disease, but appears after the pus has escaped from the bone and approaches the surface.

Loss of function is also a conspicuous clinical feature of this affection; the patient is unable to move the limb or the adjacent joint. Spontaneous fracture or separation of the epiphysis from the diaphysis may occur, or synovitis of an adjacent joint, either simple or suppurative, may be present; these latter symptoms are met with later in the disease.

Diagnosis.—The diagnosis of spontaneous osteomyelitis is often difficult at the beginning of the disease; if the infection is very virulent, the symptoms of profound septic intoxication may cause the case to resemble one of typhoid fever, but the sudden appearance and severity of the constitutional symptoms, with the continued high temperature, and the absence of the daily rise common in the early history of typhoid fever, will distinguish it from that disease. Owing to the fact that the disease is apt to start about the epiphyseal lines, there may be pain, swelling, and loss of function in an adjacent joint; the disease is very apt to be confounded with acute rheumatism, but careful examination will show that the pain is near but not in the joint, and the greatest tenderness upon pressure will be noticed over the bone near the epiphyseal line, which would not be the case in acute rheumatism; the boring, gnawing character of the pain in osteomyelitis will also serve to distinguish it from the pain of the former affection. We believe

the error of confounding osteomyelitis with acute rheumatism to be a very common one. We have seen many cases of osteomyelitis in which this mistake was made, and the error was discovered only when an abscess had formed and the presence of dead bone was demonstrated with the probe.

An early diagnosis of osteomyelitis is most important, for prompt recognition and treatment of the disease diminish very greatly the risk to the patient, the amount of destruction of the bone, and the subsequent disability.

Prognosis.—The prognosis in infective osteomyelitis is always grave; death may result in a few days from septicæmia, or later from pyæmia, and if so unfortunate a termination does not take place, the patient may be worn out by the pain and fever which are present before the inflammatory exudations perforate the bone and appear at the surface. The prognosis varies also with the virulence of the infection, as well as with the promptness and thoroughness of the treatment which is instituted.

Treatment.—No surgical affection demands more prompt operative treatment than osteomyelitis. As soon as it is evident that this disease has attacked a bone, the skin over the affected region should be carefully sterilized, and an incision should be made down to the bone. After the periosteum has been divided, in most cases serum or pus will escape, and it is not uncommon to find at the epiphyseal line some evidence of inflammation or necrosis of the bone. The bone should be trephined or cut away with a gouge, and pus is usually found when the medullary cavity is exposed. In early operations there may be merely swelling and hyperæmia of the medullary tissues. The surgeon should not hesitate to remove the bone freely, cutting away one surface so as fully to expose the inflamed and suppurating medullary cavity; the curette should also be used, and, after all the infected medullary tissue has been removed, the wound should be irrigated with a solution of bichloride of mercury, and loosely packed with iodoform or sterilized gauze. A gauze dressing should next be applied, and the limb should be placed upon a splint. Usually after such treatment the pain and constitutional symptoms disappear rapidly, and in a few days the exposed bone is covered with healthy granulations. Healing of the wound takes place rapidly, and a depressed cicatrix results.

In cases in which the operation is not done for some weeks after the beginning of the attack, more or less dead bone may be found upon making the incision; this should be freely removed, even at the expense of removing bone which is not devitalized.

To lessen the time of healing, which is necessarily slow, as it is accomplished by granulation, and to diminish the resulting deformity from a depressed scar, various methods, such as bone-grafting and Schede's method of having the cavity filled with a blood-clot, have been employed. For a successful result from any of these methods, it is absolutely essential that all infected tissue should be removed and that the cavity should be aseptic. If infection by pyogenic organisms occurs, suppuration takes place, and the material introduced does not become vitalized, and is thrown off, or remains as a dead body in the cavity and has to be removed subsequently.

The method of employing these various procedures will be described under the treatment of necrosis.

Chronic Osteomyelitis.—This affection is similar in its pathology to the acute variety of the disease, but is usually circumscribed, as the infective process is limited to a smaller area of bone-tissue; it may follow years after an attack of acute osteomyelitis, and probably results from the renewal of activity of micro-organisms which have remained latent at the site of the former inflammatory trouble until started into activity by some traumatism or constitutional infection. It is the condition which was formerly described as *circumscribed abscess of bone.*

Chronic osteomyelitis may develop in the region of the epiphysis, constituting a circumscribed epiphyseal abscess, or may occur in the region of a former suppurative osteomyelitis, causing a circumscribed abscess of the bone at that point. The bones most commonly affected are the tibia, femur, and humerus.

Chronic osteomyelitis gives rise to a circumscribed abscess containing from a few drops of pus to several ounces. The bone around the cavity is usually thickened, and the overlying periosteum may be inflamed, but rarely presents the conditions present in suppurative periostitis. Necrosis is rare, but a certain amount of caries of the bone may be associated with this affection. Chronic osteomyelitis in the region of the epiphysis may be followed by suppurative arthritis if the abscess opens into an adjacent joint. In chronic osteomyelitis, thrombosis, septicæmia, and pyæmia are rarely seen. Acute osteomyelitis may, however, develop at the site of a chronic osteomyelitis, and the affection, unless promptly treated, may produce a fatal result.

Symptoms.—In chronic osteomyelitis the constitutional symptoms are not usually marked; *fever* may be present or absent; there may be *swelling* to a slight extent, or it may be wanting. Usually, however, some thickening of the bone at the seat of disease can be demonstrated. *Pain* may be intermittent, and is of a boring or gnawing character, is increased by exercise, and is apt to be more marked at night. *Tenderness* on pressure can usually be elicited, and is probably due to secondary periostitis. The skin presents no discoloration, but *œdema* may be present if the periosteum is involved.

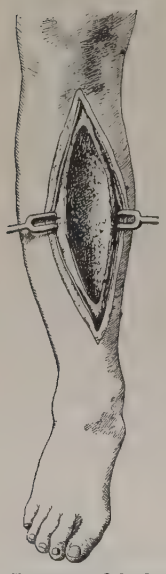
Chronic osteomyelitis, especially if it be multiple, may be confounded with syphilitic disease of the periosteum or bone. In the latter affection suppuration is rare, and the seat of the bone-lesions is not apt to be near the epiphysis, as is the case in chronic osteomyelitis. The patient also is apt to present other evidences of syphilis, and the lesions usually disappear rapidly under antisyphilitic treatment.

Chronic proliferating or sclerosing osteomyelitis may bear a strong resemblance to osteosarcoma in its clinical appearance and course, the true nature of the disease being apparent only upon exploratory incision, when the presence of typical sequestra and of pyogenic cocci in the granulation-tissue leads to the correct diagnosis. On account of this resemblance, Kocher and Jordan have called attention to the importance of exploratory incision before amputation for osteosarcoma.

Treatment.—Abscesses resulting from chronic osteomyelitis should be promptly opened and drained, especially if they arise near the epiphyses, to prevent the possibility of their opening into adjacent joints. Subperi-

osteal abscess presents marked swelling and fluctuation, and should be treated by free incision, irrigation, and drainage. The site of the abscess can usually be located by the thickening and enlargement of the bone and tissues at that point and by the œdema of the overlying skin. In operating upon these abscesses, after applying an Esmarch bandage and tube to render the parts bloodless, the bone should be exposed by incision, and the periosteum turned aside and held out of the way with retractors; the bone is then trephined or opened with a gouge, and as soon as pus is reached the walls of the cavity should be cut away until the cavity has been freely exposed (Fig. 445), when its surface should be thoroughly curetted and irrigated with a solution of bichloride of mercury. After the cavity has been thoroughly cleansed, the overhanging edges of bone should be removed with a gouge, to form a cavity with sloping edges, so that the soft parts can fall in. The cavity should then be loosely packed with gauze and an antiseptic or sterilized gauze dressing applied; or, after thoroughly cleaning the cavity, it may be allowed to fill with blood-clot, or may be filled with bone chips, and the skin may be sutured over it. It is essential that the cavity should be aseptic to obtain a favorable result by the latter method.

Fig. 445.



Exposure of the bone-cavity in chronic osteomyelitis. (After Neuber.)

Epiphysitis.—This is a disease frequently seen in infants and young children, which arises from infection of the long bones in the region of the epiphysis by pyogenic organisms, and presents many symptoms in common with acute infectious osteomyelitis; its tendency, however, is to involve the adjacent joint, setting up an acute suppurative arthritis, rather than to extend to the shaft of the bone, as is the case in the latter affection. From its tendency to involve the joints it has also been described as *Acute Arthritis of Infants.* The cases described by Mr. Thomas Smith under this name were probably cases of epiphysitis. The infection in young infants probably arises from sloughing of the umbilical cord, and the localization of the pyogenic organisms may be determined by slight traumatisms received during labor. In older children the infection may arise from an acute tonsillitis or the throat complications of diphtheria or scarlet fever, or it may be impossible to trace the source of the infection, as is often the case in acute infective osteomyelitis, the pathology of which affection is similar. In epiphysitis the pus may make its way directly through the articular end of the bone and open into the joint, or may open laterally through the periosteum and come to the surface, the joint escaping infection.

Symptoms.—In a typical case of acute epiphysitis in an infant the tissues over an epiphysis of a long bone become swollen and painful, and the limb is kept quiet; the child at the same time is feverish and restless and soon presents the constitutional symptoms of septic infection, and in a short time the joint becomes swollen and presents all the symptoms of acute suppurative arthritis, or the abscess may point upon the limb near the joint. If

the abscess has opened into the joint, rapid absorption of the cartilages occurs, and the pus soon makes its way through the capsule of the joint, or the abscess may open spontaneously through the skin. After this occurs the inflammation quickly subsides, and recovery takes place often with very little impairment of the joint motion, but the subsequent growth of the bone may be retarded. (Fig. 446.)

Fig. 446.

Deformity following arrested growth of the radius from epiphysitis. (Ashhurst.)

Treatment.—If the case be seen early, before the abscess has opened into the joint, an incision should be made over the inflamed epiphysis with full aseptic precautions, the pus evacuated, and the wound irrigated and drained and an antiseptic dressing applied. If, however, the joint has been involved before the case comes under the surgeon's care, he should open the joint by an incision, evacuate the pus, and, after irrigating it, introduce drainage and apply an antiseptic or sterilized gauze dressing and immobilize the joint by a splint. It is a remarkable fact that recovery in these cases usually takes place very promptly after free drainage has been secured, with very little joint disability resulting.

Tubercular Osteomyelitis.—This is an inflammatory affection of bone resulting from infection by the bacillus tuberculosis, which may affect the long, short, and flat bones, and may occur as a primary or a secondary affection.

Primary tuberculosis of bone, which implies that the tubercle bacilli have localized themselves in the bone and are not present in other parts of the body, is considered by careful observers to be an extremely rare affection.

Secondary tuberculosis of bone results from tubercular infection of bone from an antecedent tubercular focus, and constitutes the majority of the cases of bone tuberculosis.

Tubercular disease of bone is more frequent in males than in females after ten years of age, and is much more common in young adults than in middle life or old age. The epiphyseal region is the portion of the bone in which the localization of the bacilli is most common. Traumatism is considered by many observers to play an important part in the development of bone tuberculosis, but clinical experience would seem to controvert this view, for it is extremely rare to have subjects who are suffering from tuberculosis and have sustained an injury of the bones develop tubercular affections of the same at the seat of injury; it is probable, however, that a slight traumatism may act as an exciting cause of localization of the bacilli at the seat of injury, as is often the case in acute infective osteomyelitis. Heredity is generally recognized as an important factor in the development of tuberculosis of bone; scarlet fever, measles, diarrhœa, typhoid fever, and pneumonia are also recognized as diseases which affect the patients' general nutrition and thus render them more susceptible to the development of bone tuberculosis.

Caries of bone results from some specific irritant, which is usually tuberculous or syphilitic in character. In tubercular caries of bone the

deposit of tubercle causes a rarefying ostitis by enlargement of the Haversian canals, thickening of the periosteum, and the development of granulation-tissue, which shows the structure of tuberculous disease; caseation or liquefaction may occur, and a tubercular abscess may result. According to the changes which occur in the inflamed bone we have resulting *caries fungosa*, which is characterized by an excessive production of granulation-tissue; *caries sicca*, in which there may be extensive destruction and absorption of bone, from pressure of contiguous parts, without the production of abscess; or *caries necrotica*, in which a portion of bone surrounded by rarefying ostitis and tubercular infiltration may have its vitality so completely destroyed that it dies, giving rise to a small sequestrum. The treatment of caries of bone is similar to that of tuberculosis of bone.

Pathology.—Tuberculous infection usually attacks the cancellous structure of bone, and is therefore very common in the carpus, the tarsus, the bodies of the vertebræ, and the articular extremities of the long bones. It rarely is developed in the medullary cavity of the long bones, but occasionally involves the bones in the region of the epiphyseal lines. The first change is a rarefying ostitis from enlargement of the Haversian canals; the periosteum becomes thickened, and infected granulation-tissue forms more or less rapidly. The tuberculous deposits are surrounded by areas of inflammation, and a portion of the bone, being cut off from its nutrition, may undergo molecular death, or a mass of bone may lose its vitality, giving rise to a tuberculous sequestrum. Caseation and liquefaction of the tuberculous material may take place, producing a tuberculous abscess, composed of degenerated cells, with curdy, cheesy material, and bone detritus; this fluid, which has the appearance of pus, is really not such, unless a mixed infection has occurred through the introduction into the cavity of pyogenic organisms from the circulation, or by infection of the cavity from without. The tuberculous process may extend so as to open an adjacent joint, or may open upon the skin; in either event a sinus is left which is lined with tuberculous granulations. When tuberculous abscesses of bone have opened spontaneously upon the surface, their infection by pyogenic organisms is very common. Examination of the bone through the sinus with a probe will usually reveal softened or carious bone, and in some cases roughened bone may be felt, or a sequestrum. On the other hand, circumscribed areas of tuberculous deposits may be shut off by healthy granulations in the surrounding bone, absorption or calcification of the broken-down tissue occur, and the bone surrounding the diseased structures become sclerosed.

Symptoms.—Tuberculous disease of bone is often difficult to recognize early, and its progress is generally very slow. The most marked symptoms are pain, which may be spontaneous or be elicited only by pressure over the diseased area, and enlargement of the bone or of the soft parts over it, causing swelling, which can best be observed in exposed situations, as the extremities of the long bones. Loss of function and atrophy of the muscles are common symptoms, largely due to non-use of the part. As caseation of the tuberculous tissue advances and the material escapes from the bone, the soft parts over the diseased area become œde-

matous and sometimes red, and fluctuation can be detected; redness of the skin may be wanting, however, even when large collections of fluid can be detected. Fever is usually absent or very slightly developed, and is apt to be marked only if infection of the tuberculous tissue takes place from the presence of pyogenic organisms. If the collection of tuberculous fluid is opened or ruptures spontaneously, thin, watery fluid escapes, containing curdy and cheesy masses, with, at times, fine particles of bone, which give it a sandy or gritty feel. The sinus remaining after the escape of the fluid is lined with tuberculous granulations, which are œdematous and exuberant, and if not infected may discharge for months or years without giving the patient much pain or inconvenience.

Diagnosis.—All chronic inflammations of the cancellous structures of bones are, as a rule, tubercular in their origin, and it is only in cases of chronic osteomyelitis that an error of diagnosis is likely to occur; the latter affection is most frequently observed in young adults, and is apt to involve the articular extremity of a long bone, is slow in its progress, is more localized, and presents a circumscribed area of swelling, with tenderness on pressure over a limited extent of surface.

Prognosis.—Although spontaneous healing of a tubercular focus of bone may occur if the patient is well nourished and the diseased material is shut off by healthy granulation-tissue and later by condensation of the surrounding bone, yet this is not a usual termination after caseation and liquefaction of the tuberculous products have occurred. If, however, such a termination has occurred, the patient later is liable to re-infection from the tuberculous focus, and may develop osteo-tuberculosis years after the primary attack.

In cases in which there is no tendency to healing, sinuses form and continue to discharge, and, unless the condition is relieved by operative treatment, the patient is liable to die from amyloid changes in the viscera, from exhaustion, or from general tuberculosis. Infection of a tubercular abscess by pyogenic organisms also affects the prognosis unfavorably. The prognosis in children and young adults affected with osteo-tuberculosis is more favorable than in those in middle life or advanced in years.

Treatment.—As soon as the diagnosis of tuberculous disease of bone can be made, both constitutional and local treatment should be instituted. The former consists in improvement of the hygienic surroundings by change of climate, exercise in the fresh air, the use of a nutritious diet, and the employment of remedies which are recognized as arresting the progress of tubercular disease, iron, iodide of iron, and cod-liver oil being the most serviceable.

The local treatment of bone tuberculosis consists first in rest, which is especially applicable to the early stage of the disease before caseation has occurred. The diseased part should be put as nearly as possible at absolute rest, which tends to arrest the progress of the disease and favors the process of repair. The parts should be fixed by the application of a plaster of Paris bandage, which in the case of the extremities not only protects and fixes them, but also prevents subsequent deformity by holding them in their normal position. If properly applied, so that immobilization is secured, the

patient is able to go about and have the advantage of exercise in the open air.

Parenchymatous injections which destroy or inhibit the growth of the bacilli, such as iodoform emulsion, ten per cent., balsam of Peru emulsion, ten per cent., and chloride of zinc solution, two per cent., have recently been employed with good results. Iodoform emulsion is the remedy which is most generally used, and an injection of a drachm or two of this material is made deeply into the tubercular tissues or softened bone at intervals of a few days or a week. (See also pages 61 and 62.)

Ignipuncture.—This procedure also is employed in the treatment of localized tubercular inflammations of bone, and consists in introducing the needle-point of a Paquelin's cautery through the tissues into the tubercular focus in the bone ; one or more punctures may be made into the cavity at different points. After making the punctures an antiseptic dressing is applied, and at the end of several weeks the eschar separates, and healthy granulations cover the wounds made by the cautery. The relief from pain following ignipuncture is usually marked. Its effect is to destroy directly a portion of the tubercular products, and at the same time to stimulate tissue proliferation, substituting a plastic inflammation for a tubercular one.

Operative Treatment.—The removal of tubercular foci of disease by operation is, upon the whole, the most satisfactory method of treatment, if the disease is so situated that it can be reached without a too extensive incision in the soft parts. This procedure may be adopted early in the affection, or after the softening of the tuberculous products has taken place. Great care should be taken to sterilize the skin in the region of the wound, to prevent infection of the tuberculous area of bone by pyogenic organisms. The use of Esmarch's apparatus for the control of bleeding during the operation will be found most satisfactory. An incision should be made fully exposing the diseased bone, and the cavity thoroughly cleansed of tuberculous tissue with a curette or gouge ; the surrounding soft parts if involved should be thoroughly curetted, or the tubercular tissue should be trimmed away with scissors. Synovial pouches or the sheaths of tendons, connective tissue, and skin, if implicated in the disease, should be carefully cut away.

In operating upon cases of epiphyseal tuberculosis care must be taken to avoid opening the joint. It is a safe rule in these cases to remove the tissues freely, even at the expense of removing some non-infected tissue. After a sufficiently free removal of tissue has been effected, the cavity should be irrigated with bichloride solution, dried with gauze pads, and dusted with iodoform, and the edges of the wound brought together by sutures, or the cavity may be filled with bone chips, and the periosteum and skin sutured over them. If no suppuration occurs, the parts may be solidly healed in a few weeks ; if, however, suppuration occurs, healing does not take place promptly, and it may become necessary to reopen the wound and repeat the curetting. If sinuses already exist, and the wound is infected and discharging pus, the cavity should be exposed and cleared of diseased tissue, and should then be irrigated and loosely packed with iodoform gauze, and the external wound should not be closed. After a few days the gauze should be removed and fresh gauze packed into the wound. In these cases healing

by granulation and contraction occurs, and, to secure this object, if the cavity is a deep one the overhanging edges of bone should be removed with a gouge, to allow the soft parts to be drawn in to fill up the cavity. In all operations upon tuberculous bone the more thorough the operation the more likely is complete healing of the wound to occur.

NECROSIS.

This term is synonymous with mortification or death of bone, and corresponds to gangrene in the soft parts. In this condition a considerable portion of bone has lost its vitality and remains in the tissues as a foreign body or sequestrum. The causes producing necrosis of bone have been previously described: they are mechanical violence, which may completely separate a portion of bone and cut off its nutrition, as is sometimes seen in compound and gunshot fractures, and more commonly in infective or specific inflammation of bone, such as osteomyelitis, and tubercular or syphilitic inflammation. Pyogenic infection is the most prolific cause of necrosis, for even in traumatic separation of bone the detached portion may maintain its vitality and regain attachments to the living bone if pyogenic infection of the wound does not take place. The same is true in cases of syphilitic necrosis, which is generally due to pyogenic infection of a syphilitic inflammation of bone. Exposure to the fumes of phosphorus produces necrosis of the jaws. Exanthematous necrosis involving the jaw is often seen after scarlet fever and measles. It is probable, however, that in the case of phosphorus necrosis the irritating cause is the fumes of phosphorus, and that the subsequent necrosis results from an infective osteomyelitis; while in the case of exanthematous necrosis there is little doubt that the death of bone results from osteomyelitis caused by specific and pyogenic organisms.

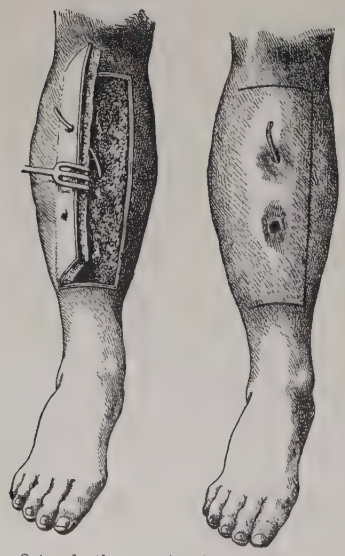
Symptoms.—The condition of necrosis is preceded by the symptoms of inflammation of bone: when the bone is actually dead few symptoms are present. The devitalized bone usually is more or less surrounded by a case of new bone which has developed from the periosteum, and the cavity of which communicates with one or more sinuses which lead to openings upon the skin. More or less granulation-tissue lines the cavity, and a little pus is generally discharged from the sinuses. The presence of a considerable portion of dead bone can be recognized by passing a probe through the sinus, when it comes in contact with the roughened bone. If the sequestrum is loose, it can be moved by pressure with the probe. (Fig. 447.) When this condition exists, the operation for the removal of the sequestrum—*sequestrotomy*—offers the best means of securing permanent healing of the sinuses. Where a small sequestrum exists, it may be loosened by the underlying granulations and escape through a sinus, or may be macerated and broken up and escape in small pieces. This spontaneous extrusion of a sequestrum is, however, not likely to occur except in the case of a very small sequestrum, and a period of years is often required for its accomplishment.

Fig. 447.

Necrosis of humerus, with exposed sequestrum. (Agnew.)

Treatment.—Sequestrotomy.—When a sequestrum exists, healing cannot take place until this is removed. The region of operation should be thoroughly sterilized, and in operating upon the long bones the use of Esmarch's bandage to render the parts bloodless will be found most satisfactory. After the circulation has been controlled, an incision should be made down to the bone, the sinuses being used as guides to the incision, and, when it is possible, the intermuscular septa being followed, to avoid transverse division or splitting of the muscular fibres. When the bone has been exposed, the periosteum should be separated and turned aside, and the involucrum or new bone surrounding the sequestrum or dead bone cut away with a gouge. When this has been sufficiently removed, the sequestrum should be grasped with forceps and removed. The edges of the involucrum should next be cut away freely, so as to expose the cavity fully and leave it with sloping edges, to favor the falling in of the soft parts in the subsequent cicatrization. (Fig. 445.) The cavity should then be thoroughly cleared of granulation-tissue with a curette, and, after being irrigated with bichloride solution or sterilized water, should be dried with gauze pads and loosely packed with iodoform or sterilized gauze, a copious antiseptic dressing applied, and after this has been secured with a firm bandage covering the whole limb, the elastic tube of the Esmarch apparatus should be removed, and the circulation allowed to return to the limb. If no large vessel has been injured, troublesome hemorrhage is not likely to occur. The after-treatment of these cases consists in the removal of the dressings and packing at the end of a week, and the introduction of a loose gauze packing and a gauze dressing applied in the same manner. If the cavity is a large one, a considerable time is required for the healing, which leaves a depressed scar, the tissues being drawn into the cavity in the healing.

Fig. 448.



Osteoplastic resection for the removal of sequestrum. (Bier.)

To lessen the time occupied in healing and to diminish the scar resulting, various procedures have been adopted. Neuber made flaps from the skin, which were turned in and fastened to the floor of the cavity by sterilized tacks. Senn has recommended the filling of the cavity with decalcified bone chips, the soft parts being subsequently closed over the cavity with sutures. Schede's method of allowing the cavity to fill with blood-clot, which becomes organized, has also been employed. Sponge-grafting has been used in these cases. Bier has practised an osteoplastic resection of the involucrum, in which a portion of the involucrum attached to the soft parts is turned aside (Fig. 448), and when the cavity is cleared of the sequestrum and granulations it is allowed to fall back over the cavity, and is secured in position by sutures or sterilized nails.

There is no doubt that by some of these various methods the time of healing and the resulting scar are diminished, but for success to follow in such cases it is essential that the wound should be aseptic: if suppuration occurs, the materials introduced are apt to act as foreign bodies, and are thrown off, or have to be removed, and failure as regards prompt healing results.

We have employed bone chips in some cases with advantage; but in the majority of cases the method of after-treatment, which consists in loose packing of the wound with gauze, is the most satisfactory. If care is exercised to see that a cavity is left, with sloping edges of bone, so that the soft parts can be drawn in during the healing, repair is usually satisfactory, and the resulting scar, if it is on a part of the body covered by the clothing, is a matter of little consequence. In cases where the involucrum is poorly developed, or has to be so freely removed as to weaken the bone materially, or where the sequestrum is removed from an exposed portion of the body, and the resulting scar would cause marked deformity, some of the methods which have been described may be employed.

TUBERCULOSIS OF THE SPINE.

Pott's Disease.—This consists in a tubercular inflammation of the bodies of the vertebræ and of the intervertebral cartilages, and is most common in children between two and ten years of age, although it may occur at any age. In some cases the affection appears to follow a slight traumatism, and unquestionably an injury may be the exciting cause in a subject who possesses a tubercular diathesis; in other cases the disease develops without apparent exciting cause. It is observed in all classes of life, but is most common among the poor, in whom ill feeding and defective sanitary conditions result in lessened resistance to tubercular infection. Certain portions of the spine are more frequently the seat of the disease than others; thus, about five per cent. are situated in the cervical region, about fifty per cent. in the dorsal region, and about thirty per cent. in the lumbar region. Atlo-axoid disease is very rare, occurring only in about one per cent. of all cases.

Pathology.—The disease usually begins as a tubercular inflammation in the cancellated structure of the bodies of the vertebræ, and may involve the anterior or the posterior surface or the body of the bone at its juncture with the intervertebral disk. The disease probably begins less commonly in a tuberculous synovitis of the intervertebral articulations, and extends to the bodies of the vertebræ secondarily. The changes which occur in the spine are those which are observed in tuberculous arthritis or ostitis in other parts of the body. The destructive process causes softening and breaking down of the bodies of the vertebræ and intervertebral cartilages. The bone and cartilages may gradually soften and break down, or masses of bone may be separated and thrown off as sequestra. The caseation and liquefaction of the affected tissues give rise to spinal abscess, so often seen in these cases. The vertebræ above and below fall together, and a backward projection of one or more spinous processes produces the characteristic angular curvature. (Fig. 449.) The amount of deformity depends upon the extent of the disease in the bodies of the vertebræ; a limited amount of destruction of the

lateral or anterior surfaces of the vertebræ may be accompanied by very little deformity. Compression of the spinal cord may result from the pressure of tubercular products between the dura mater and the bone, or, rarely, from pressure upon it of the displaced bones. The spinal nerves having their origin from the cord at the seat of disease may be pressed upon. If the disease is arrested in the early stage, before any destruction of the bodies of the vertebræ has occurred, the parts may return almost to their normal condition, no marked deformity being present, but there is apt to result more or less ankylosis at the seat of disease. If softening and breaking down of the bodies of the vertebræ have occurred, with caseation and liquefaction of the infected tissues, recovery takes place with ankylosis and great deformity at the seat of disease.

Fig. 449.

Destruction of the bodies of the vertebræ in tuberculosis of the spine. (Agnew.)

Symptoms.—The symptoms of tuberculosis of the spine vary with the stage, situation, and extent of the disease. The most prominent early symptoms are rigidity, tenderness, and local pain; later there are developed deformity and abscess, and occasionally there is implication of the nerves and spinal cord, causing paralysis. Rigidity of the spine is a very constant early symptom of this affection, due to absence of movement in the intervertebral joints, which at first is caused by protective muscular action and later by ankylosis. Rigidity can be noticed if the patient is asked to look at something behind him, when he will turn his body to do so, or, better, by getting him to pick up an object from the floor, when in stooping he bends the thighs upon the trunk and the knees upon the thighs, and does not flex the spine in the usual way. In walking or standing there is noticed the same tendency to fix the spine. The patient fixes the upper part of the spine by the aid of the trapezii and scapular muscles, which raises the shoulders and throws the arms out, and in walking the gait is a shuffling one, to avoid the jar communicated to the diseased vertebræ by high stepping. Pain in the early stage of the disease is complained of in the regions supplied by the nerves which come off from the cord at the seat of disease. In disease of the lumbar region the pain is abdominal, and may be associated with vesical irritability. In the dorsal region pain may be epigastric or intercostal, and respiration may be affected. In the cervical region pain or numbness may be felt in the arms, an irritating cough may be present, and deglutition is sometimes affected. Pain may be elicited by pressure or rough handling, and is much increased upon movement or in jarring of the spine by jumping. It will often be noticed that the patient, for comfort, will support the head and the parts above the seat of disease with the hands placed under the chin or upon the pelvis, to relieve the diseased vertebræ of the weight of the superimposed parts.

Deformity or angular curvature usually occurs later in the disease, depending upon the amount of breaking down in the bodies and the

falling together of the vertebræ, and may be gradual or rapid in its development.

Abscess may occur comparatively early in the disease, but is most common in the later stages. It is probably present in almost all cases, and may be extensive and reach the surface of the body, or may be limited in extent and undergo gradual absorption, so that its presence is not obvious. The direction which the fluid takes depends upon the seat of the disease, upon the anatomical peculiarities of the parts, and upon gravitation.

Fig. 450.

Psoas abscess. (Agnew.)

In *cervical* disease the pus may escape either into the œsophagus, lung, trachea, or pleura, or descend into the posterior mediastinum, or open at the side or back of the neck, or pass forward and project into the pharynx, forming a *retropharyngeal* abscess, which is especially apt to occur in high cervical disease. In *dorsal* disease the abscess may present upon the surface at the sides of the diseased vertebræ, or form a dorsal abscess, or open into the pleura or lung, or pass down behind the diaphragm and point in the ilio-costal space and form a *lumbar* abscess, or enter the sheath of the psoas muscle and pass down into the thigh upon the outer side of the femoral vessels, giving rise to a *psoas* abscess. (Fig. 450.) In the *lumbar* region the abscess may point in the loin, or in the ischio-rectal or the iliac fossa.

Paralysis.—This is usually motor, sensation being rarely affected, and occurs late in the disease, being caused by pachymeningitis, or by pressure of the displaced vertebræ upon the cord; wasting of the muscles is observed, and spastic palsy may be present if the disease is above the lumbar enlargement.

Diagnosis.—The importance of an early diagnosis in tuberculosis of the spine cannot be overestimated. Cases presenting symptoms pointing to this affection should be subjected to a systematic examination; the patient being stripped, the spinal column should be inspected for deformity, and its function carefully tested. Spinal rigidity is an early and very constant symptom, and may be demonstrated by making the patient stoop to pick up an object from the floor, or by placing him on a table upon his face and abdomen, when, by raising the body by the legs, the flexibility of the spine may be ascertained. When the disease is well advanced and deformity is present, the diagnosis can be made with little difficulty. The important diagnostic signs vary somewhat with the region of the spine involved in the disease.

Cervical Tuberculosis.—The position of the head is changed, the occiput being drawn downward and the chin elevated, the cervical spine is rigid, and there are reflex spasm of the neck muscles, pain in the course of the occipital nerves, elevation of the shoulders, and occasionally a projection upon the posterior wall of the pharynx, which can be felt with the finger. (Fig. 451.)

Dorsal Tuberculosis.—Here there are usually present epigastric pain, pain upon concussion, rigidity of the spine, and grunting respiration. The presence of reflex spasm of the spinal muscles, confined to one side, can also usually be elicited. (Fig. 452.)

Lumbar Tuberculosis.—In early disease of this region of the spine the attitude is usually erect, and there are some lordosis, rigidity of the spine, and pain in the course of the sciatic and anterior crural nerves; reflex muscular spasm is also usually present. (Fig. 453.)

Fig. 451.

Tuberculosis of the cervical vertebræ.

Fig. 452.

Tuberculosis of the dorsal vertebræ.

Fig. 453.

Tuberculosis of the lumbar vertebræ.

The conditions with which spinal tuberculosis is most likely to be confounded are: *Rachitic curvature*, which is frequently seen in children suffering from rickets: this curvature is a general one, involving the dorsal and lumbar regions, and disappears if the child is lifted by placing the hands in the axillæ, reappearing as soon as he stands or assumes a sitting posture, and disappearing again when he is laid upon his belly. The absence of rigidity and the disappearance of the curvature upon the manipulations mentioned serve to distinguish it from the deformity met with in tuberculosis of the spine.

Erosion of the Spinal Column.—*Aneurism* may produce rigidity, but there is no deformity of the spine, and aneurism is not met with at the time of life at which spinal tuberculosis is most common. The characteristic signs of aneurism can usually be elicited by a careful examination.

Malignant disease of the spine may produce rigidity, but is not apt to produce angular deformity. There is extreme pain in the course of the

spinal nerves, with a history of malignant disease in other parts of the body.

Hysterical Spine.—This affection may be confounded with tuberculosis of the spine, but may be distinguished from the latter affection by the fact that it occurs usually in young women who exhibit no spinal rigidity or well-defined local tenderness, and who present cutaneous hyperæsthesia and other signs of hysteria.

The *kyphotic rigidity* of old age and the rigidity and deformity of *spondylitis deformans* should not mislead the surgeon, as in these cases no other symptoms of tuberculosis of the spine are present.

Perinephric abscess may be confounded with tuberculosis of the spine, but is distinguished from the latter affection by the acuteness of the invasion, febrile disturbance, resistance to extension of the hip, and a tumor in the ilio-costal space which may cause later deviation of the spine to the opposite side.

Appendicial abscess with contraction of the hip may be confounded with tuberculosis of the spine, but the acuteness of the invasion and the abdominal symptoms will distinguish it from the latter affection.

All abscesses occurring about the hip, buttock, or back should be carefully examined for a possible spinal origin.

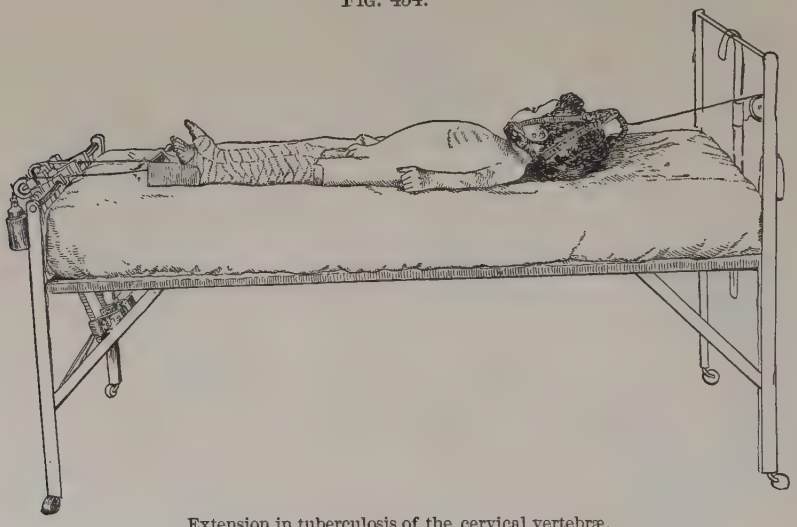
Prognosis.—Tuberculosis of the spine should always be looked upon as a serious affection. The disease runs a slow course, usually two or three years, and may terminate in recovery with ankylosis of the spine at the seat of disease, or in death from hectic fever, pyæmia, profuse suppuration, amyloid disease of the liver and kidneys, rupture of the abscess into visceral cavities, tubercular meningitis, or visceral tuberculosis. In children the prognosis is more favorable than in adults. Abscess, which occurs in the majority of cases, is less likely to develop or to assume serious proportions where treatment is instituted early in the disease. The occurrence of abscess, although it does not necessarily lead to a fatal termination, always adds to the gravity of the condition. Early recognition of the disease, prompt and judicious local treatment, and good hygienic surroundings will be followed by ultimate recovery in the majority of cases.

Treatment.—The treatment of tuberculosis of the spine consists in the use of constitutional remedies and immobilization of the spinal column. The *constitutional* treatment consists in good hygienic surroundings, good food, regular diet, the use of tonics, iodide of iron, and cod-liver oil, fresh air, and change of climate, sea air in many cases being most beneficial. The *local* treatment consists in fixing the spine and relieving the diseased and softened vertebræ from pressure, thus preventing as far as possible deformity from breaking down of the bodies of the vertebræ, and placing the diseased parts in the best position for ankylosis. Two methods of treatment are very widely employed—prolonged recumbency, and the use of spinal fixation apparatus, such as the plaster of Paris or leather jacket, or the spinal brace constructed of steel and leather.

Prolonged Recumbency.—This method consists in keeping the patient in bed upon a firm mattress with a low pillow, with sand-bags placed to the sides of the body and the head, to prevent him from turning upon

the side; the latter is especially important in cases of cervical disease. In moving a case treated by recumbency great care should be exercised not to bend the spine at the seat of disease, and moderate extension should be made at the same time. In cervical or high dorsal caries treated by recumbency the use of extension by a weight and pulley from a collar and straps fitted to the chin and occiput, and by extending apparatus applied to the feet and legs, will often be found to relieve the patient's pain and diminish the deformity. (Fig. 454.) The treatment will often have to be kept up for

Fig. 454.



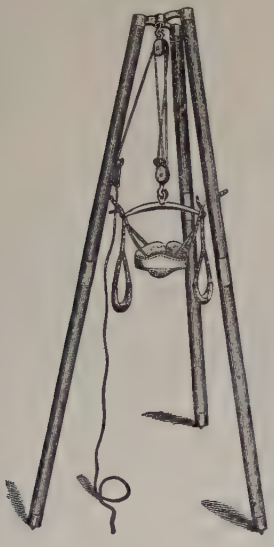
Extension in tuberculosis of the cervical vertebræ.

a period of months or even years, and, although the results are often as satisfactory as those obtained by other methods, the greatest objection urged against it is that the child cannot be taken into the fresh air, nor have a change of climate, if that be desirable. We have seen many cases treated by recumbency in which good results followed, for children seem to bear confinement to bed remarkably well if properly fed and if due care is exercised to see that the room in which they are confined is properly ventilated. Recumbency seems to be especially useful in young children, who do not bear apparatus as well as older ones, and in the earlier stages of the affection we are in the habit of keeping these patients recumbent for a few months, and later applying a supporting brace so that they can move about.

Fixation Apparatus.—The cheapest and most generally applicable fixation apparatus, and the one which accomplishes the best results, is the plaster of Paris jacket. It is applied by suspending the child from a tripod (Fig. 455) by means of arm-slings and a head-halter (Fig. 456); only moderate extension need be used, the child resting the most of his weight upon the feet. A neatly fitting woven woollen shirt is applied to the body and extends below the pelvis; a pad may be placed upon the abdomen just below the ribs under the shirt while the bandage is being applied, and removed after it has set, to allow for distention of the stomach and bowels. The plaster of Paris bandage is moistened in water and squeezed dry; the

first turns of the bandage should be passed around the pelvis just above the trochanters, and the turns should then be carried spirally up the chest to the axillary folds. A number of layers of bandage should be applied to make a dressing of sufficient firmness, four or five bandages usually being required

Fig. 455.



Tripod.

Fig. 456.

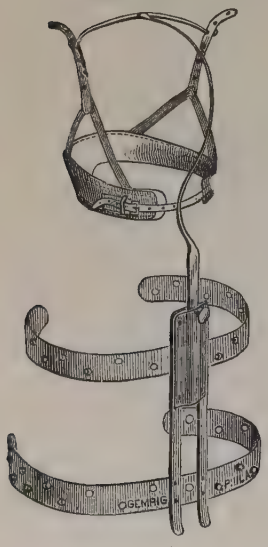
Patient suspended for application of plaster of Paris jacket.

for a child, a larger number for an adult. In a few minutes after the bandage has set the patient is lifted carefully and laid upon his back on a bed, and is not allowed to move until the bandage has become quite firm. The patient is then allowed to get up and move about. This dressing, if comfortable, need not be removed for six weeks or two months, at which time a new bandage should be applied in the same manner. In cases of cervical or high dorsal disease a jury-mast (Fig. 457) is attached to the bandage, to remove the weight of the superincumbent parts from the diseased vertebræ ; two metal strips attached to a plate are incorporated in the plaster bandage to secure the jury-mast. A leather jacket made of raw hide may be moulded over a plaster cast taken from a plaster jacket (Fig. 458) ; this is cut in front and laced so that it can be removed at times for the purpose of bathing the patient, or can be removed at night. The jury-mast may also be attached to the leather jacket.

A properly fitted metal brace, such as Taylor's, may be used to furnish fixation in cases where the patient is under careful supervision, but unless carefully applied and watched it is useless to apply this apparatus. (Fig. 459.) We have found among the poorer class of patients that the parents do not appreciate the importance of watching the case, and are apt to remove the brace and allow the child to go for days without it, interfering very materially with a satisfactory result.

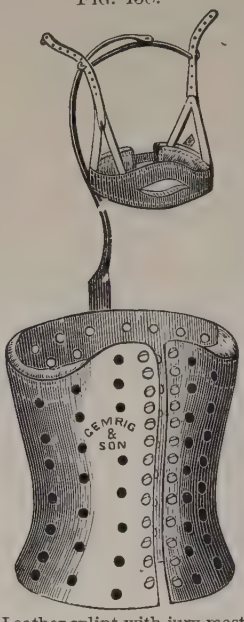
The length of time a fixation apparatus should be worn in tuberculosis of the spine is often a difficult matter to decide. It is wiser to continue the support for a longer time than seems absolutely necessary than to run the risk of removing it too soon. As a rule, support in cases which run a favorable course should be employed for at least a year or eighteen

Fig. 457.



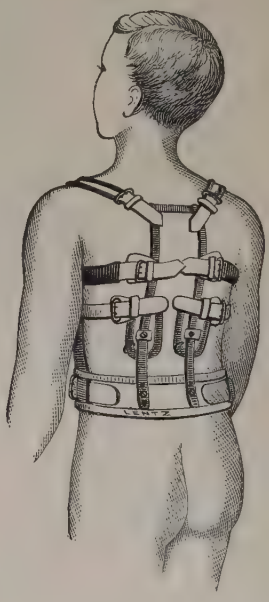
Jury-mast.

Fig. 458.



Leather splint with jury-mast.

Fig. 459.



Spinal brace.

months. Some cases require this treatment for a longer time. If the plaster of Paris jacket has been used and the case is doing well, after a year or eighteen months a leather jacket or a metal brace can be substituted for the plaster, which should be worn for a time, and can finally be dispensed with when there is ample evidence that the disease has been arrested.

Treatment of Spinal Abscess.—As before stated, abscess occurs in a large number of cases of tuberculosis of the spine, and its occurrence often prevents the wearing of suitable apparatus. A small abscess may not require operative treatment, and, if good protection is afforded by the apparatus, may undergo absorption. If, however, the abscess increases in size, the contents may be removed by aspiration or incision. Repeated aspiration, with great care as regards asepsis, is, on the whole, to be preferred to free incision. In aspirating a spinal abscess the skin overlying the abscess should be sterilized, as well as the aspirating needle; the needle is introduced into the cavity of the abscess, and the fluid is allowed to escape. Difficulty in completely emptying tuberculous abscesses is often experienced through the canula's becoming clogged with masses of broken-down cellular tissue. These may be removed by introducing the plunger into the canula and freeing its canal. After the fluid has been removed the puncture should be closed with a piece of gauze painted over with iodoform collodion. Aspira-

tion may have to be repeated a number of times, and may finally be followed by disappearance of the abscess. If the cavity fills rapidly and the skin becomes red, incision, followed by curetting, irrigation, and drainage, with closure of the wound, should be practised.

Aspiration of spinal abscess may be followed by the injection of iodoform emulsion and closure of the puncture. We have seen many cases do well under this treatment, but, upon the whole, we consider repeated aspiration the more satisfactory method.

Free incision, with curetting of the walls of the abscess when possible, is accompanied by much greater risk than aspiration, and if infection of the wound occurs the danger to the patient is much increased: hence it should be employed only when aspiration is not satisfactory. Spinal abscess in children runs a much more favorable course than in adults.

Incision and removal of the tuberculous bone have recently been practised, but the operation is attended with a definite risk to life, and seems to us to be indicated in only a limited number of cases. It is often extremely difficult or even impossible to expose the diseased area, and if a considerable amount of bone is removed with the curette the spinal column may be seriously weakened. In disease of the lower dorsal and lumbar spine, in which an abscess has opened upon the back and profuse discharge is exhausting the patient, we have practised this method of treatment with good results in some cases. The diseased bone should be exposed by incision and thoroughly curetted, and the wound drained. Where a sequestrum is present, which is not often the case, as caries of the bone is much more common than necrosis in tuberculosis of the spine, the operation is followed by the best results. *Contraction* of the thigh upon the pelvis from irritation of the psoas muscle usually requires no surgical treatment if good spinal support is furnished; if, however, it persists, weight extension may be applied, or subcutaneous or open section of the contracted structures may be practised.

Paralysis due to pressure of tuberculous exudations upon the cord, or to flexion of the cord by reason of the displaced position of the vertebræ, often disappears if the spine is properly supported, or if the patient is kept for a time upon the back, with extension made from the head and feet, or is suspended. Paraplegia from tuberculosis of the spine, although a serious complication, generally tends to a spontaneous cure, the duration of the paralysis usually being about a year. The operation of laminectomy for paralysis following disease of the spine is of service only if the symptoms are due to tuberculous exudations or displaced bone; if there is evidence of secondary involvement of the cord, resulting in acute or chronic myelitis, operative treatment should not be practised. When the conditions for operation exist, the seat of disease should be exposed by incision, and one or more of the posterior vertebral arches removed; care should be exercised not to open the spinal membranes; and if the compression is anterior it may be impossible to remove the cause. The operation should not be undertaken until more conservative methods of treatment have been first tried.

Spondylitis Deformans, or Osteo-Arthritis of the Spine.—This affection consists in a chronic osteo-arthritis which involves the verte-

bral articulations; it presents the same lesions that are found in a similar affection of other joints, and is distinct from tuberculosis of the spine. It is an affection of middle life and old age, and is rarely seen in patients under twenty-five years of age; it is more common in males than in females. It is generally observed in patients who present a rheumatic history, and often follows prolonged exposure to cold and wet. Occupation appears to have some relation to its development; those who in their work are compelled to stoop constantly, or to lift heavy weights, or to carry heavy burdens upon the back, are apt to develop this affection.

The pathological changes observed are the absorption of the intervertebral disks and the formation of osteophytes or bony outgrowths from the bodies of the vertebræ, generally occupying the lateral aspects, which by their union cause complete ankylosis of the spine. The intervertebral disks may be replaced by bone. The costo-vertebral articulations may also be involved.

FIG. 460.

Spondylitis deformans. (German Hospital Museum.)

Symptoms.—The disease begins with rheumatic aching or pain, which is followed by rigidity and gradual bending forward of the spine and the development of marked kyphosis. (Fig. 460.) When the cervical region of the spine is involved, the chin is pushed forward, the gait is changed, and lateral motions of the spine are also greatly restricted. As the disease advances, the kyphosis increases and the ribs become fixed, so that thoracic respiration is replaced by abdominal respiration. Local paralyses may result from pressure upon the nerves at the intervertebral foramina. Many persons suffering from this affection are able to carry on their ordinary occupations, and it is only when the disease has been developed to an extreme degree that the patient is unable to work or attend to his usual vocations. The disease does not seem to shorten life materially.

Treatment.—This affection is little influenced by treatment. In the early stage the use of the actual cautery applied to the region of the disease seems to have a marked effect in diminishing the pain.

SYPHILITIC DISEASES OF BONE.

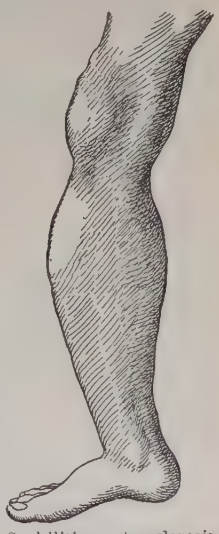
Syphilitic affections of the periosteum and bone may occur comparatively early in constitutional syphilis, but are much more frequently seen in the later stages of syphilis or in hereditary syphilis. At the present time the bone lesions of syphilis are not so common nor so extensive as they were some years ago; this is probably to be accounted for by the comparatively milder course that the disease now runs and by the fact that the treatment of the early stages of the disease is now much more thorough and prolonged. The bone lesions of syphilis may be described as follows:

Syphilitic Osteoperiostitis.—This may develop early in acquired syphilis, but usually occurs in the late secondary or tertiary stage, several years after the primary infection. The bones most frequently affected are the skull, sternum, ribs, clavicle, and tibia. The disease is manifested by the appearance of one or more tender swellings, which occur over a limited portion of one of the bones previously mentioned, and constitute the periosteal nodes, in which the disease is limited to the periosteum and the superficial layers of the bone. The pain in these swellings is generally much aggravated at night.

Treatment.—The treatment of syphilitic osteoperiostitis consists in the administration of iodide of potassium in doses of from ten to fifteen grains three times a day, or of iodide of potassium combined with small doses of biniodide or bichloride of mercury, if the patient is not already taking a mercurial. Under this treatment the pain, swelling, and tenderness usually quickly subside.

Diffused or Rarefying Syphilitic Ostitis.—This affection is observed in the later stages of the disease, either acquired or hereditary, and consists in an inflammation of the periosteum and the subjacent bone, involving the Haversian canals and the medulla of the bone, which may contain numerous small cells and extravasated red blood-corpuscles. The disease terminates in osteosclerosis, which may involve the whole shaft of a long bone. (Fig. 461.) A number of bones are usually involved in a symmetrical manner; distinct periosteal nodes are rarely observed in this affection.

Fig. 461.



Syphilitic osteosclerosis of the tibia.

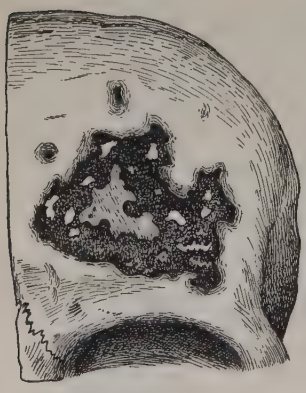
Symptoms.—The symptoms of this affection are pain and thickening of the affected bones, the pain being severe and much aggravated at night; tenderness upon pressure over the diseased bone is marked; the swelling may be apparent to the sight and touch in superficial bones, such as the tibia, ulna, clavicle, or sternum.

Treatment.—This consists in the administration of iodide of potassium in ten- to fifteen-grain doses, alone or combined with small doses of mercury, which usually gives very prompt relief from the pain and tenderness, but relapses are apt to occur in time, requiring a repetition of the treatment. Cases are occasionally met with in which in spite of this treatment the pain and tenderness do not disappear, and the patient becomes worn out by the loss of sleep. In such cases after a full trial of the treatment we have seen very prompt relief follow an incision into the inflamed bone by a saw. When this operation is done, the greatest care should be exercised as regards asepsis, for if microbic infection occurs in the wound, caries or necrosis, followed by a persistent sinus, may result. The bone over the seat of greatest pain should be exposed by an incision several inches in length, in the long axis of the limb, through the soft parts and the periosteum; a Hey's saw may then be used to make an incision which opens the medullary cavity of the bone: great thickening of the bone is often found in these cases. After

the medulla has been opened for several inches, the wound is irrigated and an antiseptic gauze dressing is applied. Pain is usually promptly relieved by this operation, and the wound if not infected heals promptly.

Gummatous Osteoperiostitis or Osteomyelitis.—This consists in a circumscribed osteoperiostitis with an abundant subperiosteal deposit of embryonal tissue, accompanied at the same time with more or less diffused osteosclerosis. In these cases there is a proliferation of the cells within the Haversian canals, which may cause absorption of the osseous tissue, giving rise to rarefying ostitis; some portion of the inflammatory infiltration may soften and present the characteristics of a gumma, while other portions become organized, obliterating the Haversian canals and causing a condensing ostitis, which results in eburnation or sclerosis of the bone. Osteosclerosis may interfere with the nutrition of the adjacent bone and result in caries or necrosis. If only the periosteum and superficial layers of the bone are involved, recovery may take place without either of these conditions resulting, but if the deeper portions of bone are involved, caries or necrosis is likely to occur. (Fig. 462.)

Fig. 462.



Syphilitic caries of the skull. (After Treves.)

In syphilitic necrosis and caries, owing to the diminished vascularity of the adjoining bone, the separation of the dead bone is a slow process, often occupying years.

Symptoms.—Pain, which is worse at night, is a most marked symptom in this affection. In bones in exposed situations there is observed a localized elastic swelling, which may in parts present the symptoms of fluctuation; the skin over the swelling becomes thin and red and may eventually give way, and a thin watery fluid be discharged. If infection occurs by pyogenic organisms, a purulent discharge issues from the sinus. Examination of the sinus with the probe usually reveals the presence of roughened or carious bone at its bottom.

Treatment.—In gummata, if spontaneous opening has not occurred, even though the skin be thin and red, prompt improvement and final disappearance of the swellings may take place under the use of iodide of potassium in doses of from ten to thirty grains three times a day. If the swelling has opened spontaneously the effect of treatment is much less satisfactory, and caries or necrosis of the affected bone is more likely to occur. The temptation to open gummata if the skin is thin and red is great, but should be resisted, for such swellings, under the administration of iodide of potassium, will often disappear; whereas if they are opened, caries or necrosis of the bone is very apt to occur, and a persistent sinus results.

Bone Lesions in Hereditary Syphilis.—In inherited syphilis lesions of the bone are frequent, periosteal nodes, osteoperiostitis, with marked hypertrophy and deformity of the bones, and gummatous osteoperi-

ostitis, being frequently observed. The lesions are most common in the long bones, and are apt to be symmetrical, and accompanied by other evidence of hereditary syphilis, such as keratitis, depression of the nasal bones, and changes in the teeth. The bone lesions are apt to be manifested between the sixth and the eighteenth year, and the tibia and ulna seem to be the bones most frequently affected. (Fig. 463.) The disease may be confounded with rachitis or tuberculosis, but the nature of the disease can usually be clearly demonstrated by the presence of other evidence of hereditary syphilis.

Fig. 463.

Syphilitic osteoperiostitis of the ulnæ.

Syphilitic Dactylitis.—This affection is common in hereditary syphilis, and consists in an osteoperiostitis of the phalanges of the fingers, which sometimes originates in the fibrous tissues over the bones. Swelling is first observed over one or more phalanges, which gradually increases in size, and spontaneous opening is apt to occur, followed by caries or necrosis and the loss of one or more phalanges. The disease is often symmetrical. (Fig. 464.)

Treatment.—In cases of hereditary syphilis of the bones, iodide of potassium in doses appropriate for the age of the patient should be employed; young children do not bear iodide of potassium as well as adults; it often produces irritation and inflammation of the nasal and laryngeal mucous membranes, so that its effect should be carefully watched. Small doses of iodide or bichloride of mercury are often more efficient than iodide of potas-

Fig. 464.

Syphilitic dactylitis.

sium. Where nodes are present and in cases of early dactylitis the local use of equal parts of mercurial and belladonna ointments will often be found of service. Clinically we have found the use of iodide of iron and cod-liver oil of great value, particularly in those cases in which iodide of potassium cannot be taken. The progress of the disease may often be arrested by antisyphilitic treatment, but more or less thickening and deformity of the bones remain permanently.

Hypertrophy of Bone.—True hypertrophy of bone unassociated with osteosclerosis is rarely met with, but occasionally cases of congenital hypertrophy of a whole limb have been observed, in which the bones of the part

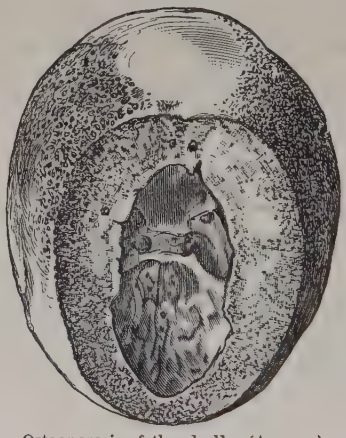
were hypertrophied. In very muscular subjects the bones subjected to excessive use may show increase in length and thickness, as well as hypertrophy of the ridges for muscular attachments. In parallel bones, when one bone is partially destroyed by disease, hypertrophy of the other bone is often observed. The hypertrophy which is often seen in the skull and in other bones is generally due to chronic osteomyelitis and osteosclerosis. (Fig. 465.) The term osteoporosis is also applied to this affection, and the best examples of this disease are observed in the skull. (Fig. 466.) No special treatment is indicated for this condition.

Atrophy of Bone.—This condition is much more common than hypertrophy of bone, being shown by diminished solidity, thickness, and length, and usually results from defective nutrition. The bone becomes more porous, the medulla and cancellous tissue are increased in size and filled with fat, and the cortical portion is so wasted that it represents but a fraction of its normal thickness. (Fig. 467.) Atrophy of bone may result from many causes, and may occur at any period of life, but is most common in advanced age. It may result as a temporary condition after fracture, when a bone has had its function suspended for a long time, or may be observed in old age, when diminished function and defective nutrition both conduce to atrophy elsewhere as well as in the bone. The best examples of atrophy of bone are seen in cases of infantile paralysis, when the bones of one or both limbs remain wasted, while other bones in the body attain their normal proportions. Malignant disease is said to produce atrophy of the bone. In this disease the bones often become weaker, so that they are liable to fracture, but we know of no observations which prove that there results actual atrophy of the bones.

Fig. 465.

Osteosclerosis of the femur. (Agnew.)

Fig. 466.



Osteoporosis of the skull. (Agnew.)

Fig. 467.

Atrophy of the femur.

Treatment.—In atrophy of bones occurring in old age little can be done in the way of treatment, but in atrophy resulting from fracture or infantile paralysis attempts should be made to increase the nutrition of the affected bones; this may be done by the use of passive motion and massage, and in conjunction with this treatment Esmarch's elastic bandage or constrictor may be applied at frequent intervals for a limited time, to produce temporary hyperæmia of the limb. Care should always be exercised in handling bones which present evidences of atrophy, as they are more susceptible to fracture than normal bones. When this accident occurs in such bones union usually takes place satisfactorily.

Osteomalacia.—Mollities Ossium.—This disease is observed in adults, and is characterized by softening of the bones, which renders them very liable to break or bend upon the application of little force. The condition is seldom seen in males, occurring with much greater frequency in females, in the proportion of about ten to one; pregnancy and lactation seem to be the principal exciting causes. The softening of the bones results from absorption of the earthy matters; the decalcified osseous tissue is finally converted into a gelatinous mass, surrounded by a thin cortical layer of bone beneath the periosteum.

Symptoms.—The premonitory symptoms are failure of health and wandering pains in the affected bones; the urine contains an abundance of phosphate of lime. In pregnant or nursing women the bones of the pelvis are first involved, but later other bones are affected. Bending of the bones or fracture may occur upon the application of little force, such as turning in bed or lifting the patient. In advanced cases multiple fractures are common. Bending or distortion of the bones may be caused by muscular action.

Treatment.—General tonic treatment is indicated, and the use of phosphorus is said to have an effect in arresting the development of the disease. The patient should be placed upon an air- or water-bed, and if there is a tendency to deformity of the bones of the limbs, light splints should be applied to prevent it. If the disease develops during lactation, this should be arrested, and if it occurs during pregnancy, the induction of premature labor should be practised. Removal of the ovaries in the non-pregnant state has been employed with apparently good results in a few cases.

Fragilitas Ossium.—This is an affection of bone in which the inorganic are out of proportion to the organic constituents, rendering the bone brittle; there is an apparent increase of the earthy salts, with a diminution of the vascularity of the bone. It may occur as a result of malignant cachexia, in general paralysis, in tabes, and in the early stage of rachitis, and is probably due to defective innervation. There are, however, persons presenting excessive brittleness of the bones, who are apparently healthy in other respects and have suffered from none of the diseases named. Children and young persons seem to suffer most from fragilitas ossium, and in many instances an hereditary tendency can be traced. Such patients suffer from fracture upon the slightest provocation, but in time outgrow the tendency. There seems to be no special inclination to non-union in these cases, fractures uniting promptly, even when several have occurred in different bones of the skeleton at the same time.

Ostitis Deformans.—This disease of bone was first described by Paget, and begins in middle life or later; it is characterized by a change in the size, shape, and direction of the diseased bones, the general health during the development of the osseous lesions being only slightly affected. The disease commonly affects the long bones of the lower extremity or the skull first, but in time the bones of the spine, ribs, pelvis, and upper extremity are involved. The bones become enlarged and softened, gradually presenting marked curving and deformity. The disease apparently starts as a rarefying ostitis, in which the normal compact tissue becomes porous and reticulated, this thickening of the compact tissue involving the walls of the shaft as well as those of the articular ends of the bone. New bone is formed beneath the periosteum, and in time undergoes hypertrophic and sclerotic changes. In addition to the deformity and change in the thickness of the bone, there is increase in length or hypertrophy. (Fig. 468.)

Fig. 468.

Ostitis deformans. (Ashhurst.)

Symptoms.—Patients suffering from this disease sometimes complain of rheumatic pain in the lower limbs and spine, but the general health is usually very little affected. The decrease of stature, stooping figure, and apparent increase of length in the arms when in the erect position usually attract attention. Bowing of the spine and loss of movement of the ribs in respiratory action are marked when the spine is involved; in such cases the breathing is largely diaphragmatic. The disease does not apparently shorten life; one of Paget's original cases lived to be seventy years of age. We have had under observation Ashhurst's case of ostitis deformans for more than ten years, and, aside from increased deformity and lessened ability to take exercise, the patient's condition is not very different from what it was at the time we first saw him.

Exostosis.—This condition consists in a local hypertrophy of bone, which usually occurs in the region of the epiphyses of the long bones, but also is observed in connection with the bones of the cranium and face. These growths are often observed at the inner surface of the femur just above the condyle, over the head of the tibia (Fig. 469), and about the phalanges of the fingers and toes. Ungual exostosis of the toes is a not uncommon affection. (Fig. 470.) These growths are composed of cancellated tissue covered by a thin layer of compact tissue. Their supposed origin from adjacent bursæ has given them the name of *exostosis bursata*, but the bursæ which form over these growths are often found to be entirely unconnected with adjacent bursæ, and are of the nature of the adventitious bursæ observed in other locations. The disease seems to possess no hereditary tendency, and there is no evidence that it depends upon syphilis or rheumatism, but it may have some connection with rachitis, representing an increased bone production after recovery from that disease. The affection is often multiple, and if the growths are largely developed the motion of adjacent joints may be markedly interfered with.

Treatment.—In the early or developing stage of exostoses such remedies as arsenic, phosphorus, and cod-liver oil may be used with benefit. Operative treatment for their removal should be undertaken only when the growths cause great deformity or interfere with the movements of adjacent joints. In removing exostoses the part should be rendered bloodless by the use of Esmarch's bandage, and the greatest care should be observed as regards asepsis. The bony growth should be exposed by incision and the soft parts carefully separated, the periosteum being saved, to expose the base of the tumor, which should be separated from the bone by a chisel or by bone forceps.

FIG. 469.

Skiagraph of an exostosis of the tibia (Willard) by Professor Goodspeed.

FIG. 470.

Ungual exostosis.

The removal of an ungual exostosis is accomplished by exposing the bony growth by incision and dividing its base with bone forceps, after its removal the skin incision being brought together by sutures.

FIG. 471.

Leontiasis ossea. (Ashhurst.)

Leontiasis Ossea.—This is an affection which has been described by Virchow, characterized by hyperostosis of the facial and cranial bones. Large masses of bone develop from the facial or cranial bones. This change in the bones does not consist in a simple outgrowth, but the whole bone is hypertrophied or involved in the growth. (Fig. 471.) The principal symptoms of the affection are pain, great deformity, and loss of function, which is caused by the growths; the eyes may be pushed from their sockets, and the nerves so compressed at their foramina of exit as to have their function arrested; loss of sight is not an uncommon complication in

these cases. The affection runs a slow course, and it may be years before the deformity or pain is marked.

Treatment.—In unilateral cases where there is distinct evidence of localized nerve-pressure, operative treatment may be undertaken, but, as a rule, where the disease is widely distributed, little can be done for the patient's relief by surgical procedures.

RACHITIS, OR RICKETS.

This is an affection which arises from malnutrition, being principally observed in infants and children, and is characterized by constitutional disturbances and marked changes in the bony skeleton. It is met with principally among the poorer classes, with whom improper food and imperfect hygienic surroundings are common, but may occur among those of the better class if improper diet is employed. Children who are fed upon the breast rarely develop rickets, unless the lactation is prolonged or the milk becomes of a poor quality from a coincident pregnancy. Artificial feeding with foods which contain a large amount of starch or with skimmed milk deficient in fatty matters, and diseases of the gastro-intestinal canal which impair the digestion and the assimilation of food, are also important factors in the production of this disease. In America the disease is less common, even in large cities, than abroad, and is most commonly observed in colored and Italian children. The disease has rarely been observed as a congenital affection, but usually develops from the sixth month to the end of the second year, and may occur as late as the fifth or sixth year. Late rickets has been observed from the ninth to the thirteenth year, but at this time of life the affection is rare, and the disease in such cases is probably a recurrence of rickets which had previously existed and had escaped notice or had been imperfectly cured.

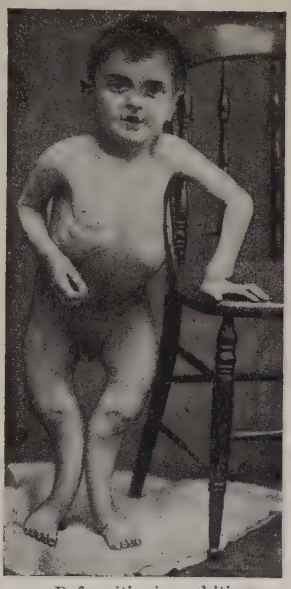
Pathology.—In rickets the most marked changes in the bone are observed at the epiphyseal junctions; there is increased growth of the epiphyseal cartilages and subperiosteal layers of bone in this region, with deficient deposit of lime salts and increased absorption of osseous tissue. The epiphyseal ends of the bones become rounded and swollen, so that they present marked enlargements. The cartilage on section is semi-transparent and in parts abnormally vascular. The periosteum is thickened and vascular, and when stripped from the bone contains numerous fragments of ill-formed osseous tissue, and the bone beneath is red, soft, and spongy, so that it can be readily cut with a knife. In this softened condition of the bones, the weight of the body in walking and crawling and muscular action exaggerate the normal curves, so that marked deformities result. The limited growth of the bones in length makes the deformities more noticeable. Rachitic deformity of the thorax, consisting in an anterior projection of the chest, with thickening or beading of the epiphyses, involving both the ribs and the cartilages, and constituting the rachitic rosary, is very common. Deformities of the spine are also common, and consist in kyphosis (Fig. 472), lordosis, and scoliosis. The skull presents the following changes: the sutures are imperfectly united, the fontanelles are enlarged or remain open; portions of the skull are ossified, and other portions become very thin, so that

soft yielding spots can be detected, the condition known as *craniotabes*. The frontal portion of the skull is unduly prominent, the skull is broadened, and the face appears unnaturally narrow and sharp. The pelvis also undergoes changes; the iliac bones become flattened, the promontory of the sacrum is pushed forward, and the lateral walls of the pelvis are flattened. The long bones present very characteristic deformities; the epiphyses are enlarged, most markedly at the wrist and elbow, knee and ankle, and the bones become curved, either anteriorly or laterally, so that

Fig. 472.

Rachitic curvature of the spine.

Fig. 473.



Deformities in rachitis.

the deformities which are recognized as bow-leg, knock-knee, and anterior tibial curvature result. (Fig. 473.) Dentition is much delayed; the first teeth may not appear until the tenth or twelfth month, and the subsequent eruption of the teeth is retarded and irregular.

Symptoms.—In infants the earliest symptoms of rickets are restlessness at night, profuse perspiration of the head, constipation, and swelling of the belly. In older children, inability to sit upright and delayed dentition and tardiness in walking may first attract attention to the disease. The epiphyses are enlarged, and examination will often reveal curvature of the spine, changes in the shape of the head and breast, and marked curvatures in the long bones. The patients may present chronic bronchial catarrh, and have sometimes attacks of laryngismus stridulus. The most important diagnostic symptoms of the disease are enlargement of the epiphyses, delayed dentition, and open fontanelles.

Treatment.—When the disease is recognized early and treatment is begun promptly, the prognosis is good, the patient's general condition improving rapidly and the deformity disappearing in a large proportion of the cases. The most important part of the treatment of rickets is change or regulation of the diet; fresh milk properly diluted should be substituted for prepared foods; meat juice or raw meat should also be given. Care should

be taken that the child has the benefit of sunlight and fresh air, and salt-water bathing may be employed with advantage. The condition of the digestive tract should be carefully investigated, and pepsin, bismuth, and tonics are often required. As regards medication, the use of cod-liver oil is most satisfactory; in infants it is not well borne by the stomach, and may be used by inunction, being rubbed into the skin of the belly and groins; in older children it can be taken by the mouth. Syrup of iodide of iron should also be given in doses proportioned to the age of the child. Phosphorus and the lactophosphates of lime are used with advantage. Infants and young children should be kept recumbent as much as possible during the early stage of the disease, with a view of diminishing the deformity which results from the weight of the body. In the early stage of rachitis, deformities of the bones of the extremities may be corrected by the use of splints and bandages. The correction of deformities of the bones resulting from rickets will be considered in the article upon Orthopædic Surgery.

CHAPTER XXI.

SURGERY OF THE JOINTS.

INJURIES OF JOINTS.

Contusions of Joints.—Contusions of joints result from blows or falls, and the damage done to the joint structures varies with the amount of force employed and the character of the articulation. Severe contusions may be followed by laceration of the ligaments and synovial membranes, detachment of the cartilages, and injury of the articular ends of the bone, and at the same time the joint becomes distended with blood, while in slight contusions the only injury done to the joint may consist in a bruising of the periarticular tissues, with slight extravasation of blood. Slight contusions of joints in healthy subjects are usually rapidly recovered from, but in weak or tuberculous subjects such an injury may be the exciting cause of a destructive tuberculous affection of a joint, or in other cases of abscess or necrosis of the ends of the bones, or of a sarcoma. In patients advanced in years, contusion of the joints, even when slight, may be followed by a form of chronic arthritis, with roughening of the articular surfaces and calcareous deposits, and in some cases absorption of the articular ends of the bones may result, giving rise to loss of function and shortening, as has been observed in the hip-joint.

In severe contusions with laceration of the ligaments, synovial membranes, and articular cartilages, and effusion of blood and serum into the joint, the effusion may be gradually absorbed, but masses of fibrous material are apt to be left, which interfere with the motion of the joint, producing more or less ankylosis; if the articular cartilages have been detached and have undergone absorption, bony ankylosis may result. Severe contusions may also be followed by gangrene of the damaged and distended skin and subcutaneous tissues over the joint, or suppuration may occur in the joint, even if the skin is not injured; in such cases the pyogenic microbes gain access to the joint by means of the blood-vessels, their point of entrance in many cases being undiscernible, suppuration in these cases being probably determined by the diminished resistance of the tissues at the point of injury.

Treatment.—In view of the fact that slight contusions of joints are often followed by serious consequences, all contusions, whether slight or severe, should receive careful attention. The first indication in the treatment of such injuries is to put the joint at rest, by the application of a splint or by placing the patient in bed; elastic pressure by means of a rubber or flannel bandage, or cold by means of an ice-bag, or cold irrigation, may also be employed with advantage: in some cases warm applications are more comfortable to the patient and are followed by equally good results. After the

effusion has been absorbed and the swelling diminished, massage and passive motion should be employed, but this should not be practised until several weeks have elapsed after the injury. After joint contusions more or less impairment of motion and pain may exist for months. If suppuration occurs in the joint after contusion, the joint should be freely opened, with full antiseptic precautions, and irrigated, gauze drains or tubes being passed through the joint, and a copious gauze dressing and splint applied, or continuous irrigation with a warm solution of bichloride or sterilized water may be used for a few days. The surgeon should bear in mind the possibility of ankylosis following, and keep the limb in the most favorable position for use should such a condition result.

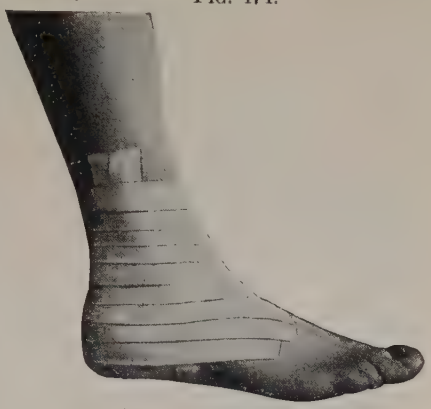
Sprains of Joints.—These injuries consist in a violent wrenching or twisting of a joint, accompanied by stretching or laceration of the ligaments, with effusion of blood and serum into the joint and into the extra-articular tissues. In slight sprains little damage to the ligaments and sheaths of the tendons may result; in severe sprains the ligaments and synovial membranes and the sheaths of surrounding tendons or fibres of contiguous muscles may be torn and tendons displaced; in some cases the insertion of a ligament or a tendon into a bone may be separated with a thin shell of bone, resulting in an injury which has been described as a *sprain fracture.*

Diagnosis.—As swelling is usually marked after severe sprains, it is often difficult to distinguish this class of injuries from fractures, and we consider it wise in such cases to give an anæsthetic, so that a careful examination of the part can be made and the absence of fracture demonstrated. In children care should be taken not to confuse sprains of joints with *epiphyseal separations*, which present very similar symptoms. Laceration of tendons, effusion of blood into their sheaths, and avulsion from their sheaths are conditions which often complicate severe sprains, and are probably the causes of persistent pain and delayed restoration of function in many cases.

Treatment.—The early treatment of a sprain consists in reducing displaced tendons, in putting the part at rest by means of a splint, and in the use of hot or cold applications, or of elastic pressure by means of the rubber or flannel bandage. Anodyne applications, such as lead water and laudanum, may also be employed, and later fixation may be obtained by the plaster of Paris or silicate bandage, after wearing which for a time, massage is often of the greatest service. In slight sprains daily massage, the application of a supporting bandage, and the use of the joint are often all that is necessary. A satisfactory treatment for sprains, which is applicable both in the early and in the later stages, is *strapping*, the region of the joint being covered with layers of rubber or adhesive-plaster straps firmly applied, which serve to fix the joint and at the same time to make pressure and limit the effusion if applied early, or to hasten its absorption if used later. Since we have employed this method, recommended by Gibney and Cotterell, we have seen the function of the part re-established much earlier. In applying strapping in sprains of the ankle or the tarsus, strips of rubber adhesive plaster one and a half inches in width and eighteen inches in length are required. The first strap is started at the junction of the middle and upper part of the leg, either upon the inner or the outer side, and applied

closely to the edge of the tendo Achillis, and carried across the sole of the foot to the base of the great or little toe; several of these straps are applied, covering in the inner or outer side of the ankle. A strap is placed with its middle at the point of the heel, the ends being carried to a point on the foot at the junction of the metacarpal bones and the tarsus; a number of these ascending straps are applied in an imbricated manner, until the ankle-joint is covered in. The straps should not be applied so as to meet in front of the foot or ankle and make circular constriction. (Fig. 474.) After the ankle has been strapped as above described, the foot and ankle are covered with a gauze bandage, and the patient is allowed to walk upon the injured foot. In the chronic stage of sprains, where the restoration of function is retarded, forcible movements of the joint under anæsthesia to break up adhesions will often promptly restore its usefulness. In sprains associated with wasting of the muscles the use of faradism will frequently be followed by good results.

Fig. 474.



Strapping of a sprain of the ankle.

Wounds of Joints.—These are among the most serious injuries that come under the care of the surgeon, the gravity of the injury depending upon the anatomical peculiarities of the joint involved, the size of the wound, and the presence or absence of infection of the wound. Aseptic joint wounds made by the surgeon heal promptly without constitutional disturbance, but a wound made by a dirty instrument, or one which becomes infected subsequently, may cause suppuration of the joint, which may result in the loss of the limb or the death of the patient. We have seen a puncture of the knee-joint from a dirty table-fork followed by acute septic arthritis which subsequently required amputation of the thigh.

Symptoms.—In extensive wounds in the region of joints the fact that the joint has been opened can be ascertained by inspection, but in small gunshot or punctured wounds it is often difficult to ascertain definitely that the joint has been opened. The most reliable symptoms which point to this injury are the escape of synovial fluid and the rapid swelling of the joint from an effusion of blood. Wounds of bursæ and the sheaths of tendons in the region of joints will be followed by the escape of synovial fluid, but, as the treatment of both injuries is very similar, it would not be justifiable to enlarge the wound or to probe freely to ascertain the exact location of the wound, but the case should be treated as one of joint wound.

Treatment.—In punctured and small wounds of joints, the skin surrounding the wound should be sterilized, the wounds being washed out with sterilized water or a 1 to 2000 bichloride solution, and closed by sutures or a scab of gauze and iodoform collodion, and a gauze dressing applied over this. The joint should then be immobilized by the application

of a plaster of Paris bandage. If no infection of the wound has occurred, repair takes place rapidly and the function of the joint is not impaired. If, however, the joint in a few days becomes swollen and painful and the patient exhibits constitutional symptoms, the wound should be exposed, and, if purulent matter escapes, the joint freely opened by incision and thoroughly irrigated with a 1 to 2000 bichloride solution, and large rubber tubes or gauze drains introduced, or continuous irrigation may be employed. In complex joints like the knee-joint it is often difficult to secure free drainage from all the pouches, and, if not properly drained, pus may burrow up the thigh beneath the quadriceps muscle, so that care should be taken to introduce a number of tubes to secure drainage. Extensive wounds involving the joints should be irrigated and foreign bodies removed, and, if the edges of the wounds are not severely contused, a few sutures should be applied at intervals, and drainage-tubes introduced through the joint. If, however, there is much laceration of the soft parts, the wound should be treated as an open one, a copious gauze dressing being applied, and the joint fixed upon a splint or by a plaster of Paris bandage fenestrated over the region of the wound. Even in cases in which the joints have been extensively opened by wounds, if infection can be prevented and proper treatment instituted, repair may take place with a useful joint. We had recently under our care a patient who had received an extensive wound of the knee-joint, produced by a butcher's cleaver, which divided the patella transversely and opened the joint; in this case, after suture of the patella and free drainage of the joint, it was closed, and the patient recovered with a useful limb.

In wounds of joints the fact should not be lost sight of that ankylosis may occur, and is especially likely to follow if suppuration and destruction of the articular cartilages have occurred, and the surgeon should be careful to fix the limb in such a position as would render it most useful if this result ensues. Excision or amputation may be subsequently required if disorganization of the joint has taken place. In wounds of joints of the upper extremity excision may often be practised with good results, and also in the ankle and tarsal joints; amputation is sometimes demanded in joint wounds of the lower extremity.

Gunshot Wounds of Joints.—Gunshot wounds of joints may be extra- or intra-articular; the former may be considered as simple flesh wounds, and are not serious injuries unless the joint be opened by subsequent sloughing of the tissues over it. Intra-articular wounds result from direct perforation of the joint by the ball, and are accompanied by injury of the synovial membrane, cartilage, and bone, often presenting great comminution of the latter tissue, and are always most serious injuries. (Fig. 475.)

The principal danger in gunshot wounds of joints is from infection of the wound, causing septic arthritis, resulting in septicæmia or pyæmia or the total disorganization of the joint.

Diagnosis.—The diagnosis of this injury is made by observing the course of the ball, the escape of synovial fluid from the wound, the distention of the joint with blood and serum, and the loss of function. Gunshot wounds of the bursæ in the region of joints may be accompanied by the escape of synovial fluid. Probing in gunshot wounds of joints, undertaken with a view of

establishing the diagnosis or locating the position of the ball, should not be resorted to, for much damage may result from this procedure, and little good can be accomplished.

Treatment.—In gunshot wounds of joints in which there is great laceration of the soft parts or extensive comminution of the articular ends of the bones with injury of the principal blood-vessels and nerves of the region, amputation should be employed, while in cases where the vessels have escaped injury and the bone injuries are less extensive, excision may be resorted to. At the present time, however, even in extensive gunshot wounds, the expectant method of treatment may be practised with safety, consisting in the employment of rigid asepsis and the removal of loose fragments of bone, or of the ball, if it can be located without difficulty, irrigation of the wound, introduction of drainage, the application of an antiseptic gauze dressing, and fixation of the joint by splints or the plaster of Paris dressing. If suppuration occurs in the wound, excision or amputation may be subsequently required; but if the wound runs a favorable course, recovery may follow with more or less impairment of function of the joint or with complete ankylosis. Bearing in mind the latter possibility, the surgeon should keep the joint in the position in which it would be most useful should this result follow.

FIG. 475.

Gunshot injury of the knee-joint. (Army Medical Museum.)

In simple penetrating or perforating wounds of joints met with in civil practice, which are not usually accompanied by extensive bone injury, the expectant method of treatment should be employed. The skin surrounding the wound should be sterilized and the wound irrigated with a 1 to 2000 bichloride solution. The wound should be dressed with a copious gauze dressing, and the joint fixed upon a splint or by the application of a plaster of Paris dressing. At the end of several weeks, if the wound has remained aseptic, it will be firmly healed, and at this time the splint may be removed and massage and gentle passive movements practised to re-establish the joint function.

DISLOCATIONS.

A dislocation or luxation is a displacement of the articular surfaces of the bones which enter into the formation of a joint. **Diastasis** is the separation at the junction of one bone with another, and is principally seen in the bones of the pelvis, at the symphysis pubis or the sacro-iliac junction. Dislocations may be **complete**, when the bones which enter into the formation of a joint are entirely separated from one another; or **incomplete** or *partial*, when portions of the articulating surfaces of the bones remain in contact with one another; this form of dislocation is often described as a *subluxation*. Dislocations are also classified as **traumatic**, when the displacement of the bones results from the sudden application of force; **pathological**, when the displacement of the bones results from alteration in a diseased joint, or from

paralysis of the muscles holding the bones in contact; and **congenital**, when present in the joints at birth. Dislocations may also be classified as **simple**, when the displaced articular surfaces of the bones are not exposed to the air by a wound in the soft parts; **compound**, when the displaced ends of the bones are exposed to the air by a wound of the overlying soft parts, produced either by the force which caused the displacement or by rupture of the surrounding soft parts by the displaced bones; and **complicated**, when in addition to the displacement of the bones there is a fracture involving one or both of the displaced bones, or laceration of an important artery, vein, or nerve. A **primitive** dislocation is one in which the bones remain in the position in which they were first thrown by the luxating force, while in a **secondary** or **consecutive** dislocation the original position of the displaced bone is changed, by a continuance of the displacing force, by muscular contraction, or by manipulations in attempts at reduction. The terms *recent* and *old* are also applied to dislocations. A **recent** dislocation is one in which no marked inflammatory changes have occurred in the articulating surface of the bones or in the surrounding tissues. An **old** dislocation is one in which changes have occurred in the articular surfaces of the bones and the surrounding tissues. The terms recent and old are not used to indicate the time which has elapsed since the receipt of the injury, but rather the rapidity with which changes hindering the reduction of the dislocation have occurred; for instance, a luxation of the elbow-joint is an old dislocation at a much earlier period than one of the shoulder-joint.

Causes.—The *exciting causes* of dislocation are violence, either directly or indirectly applied, and muscular contraction; the latter is probably a much less active factor in the production of dislocations than in that of fracture. Force may act directly upon the articulation, producing a dislocation, or may be indirectly applied, as in the case of dislocation of the head of the humerus or the head of the femur from falls upon the hand or the foot respectively.

The principal *predisposing causes* of dislocation are: **Form of the Articulation.**—Ball-and-socket joints, from the range of movement which they permit, are more liable to dislocation than ginglymoid or hinge joints; the comparative frequency of dislocation of the shoulder-joint as compared with that of the elbow-joint is explained by this cause. **Age.**—Dislocations are very uncommon in childhood, because of the absence of great muscular power, the presence of epiphyseal cartilages, and the flexibility of the soft parts about the joints. They are most common in adult life, but are not common in advanced age. **Sex.**—Dislocations are much more common in males than in females, for the reason that males are much more exposed to the exciting causes of dislocation. **Defective Articular Development.**—The imperfect development of the articular cavity or the articular ends of the bones may act as a predisposing cause of dislocation. *Muscular paralysis* producing relaxation of the ligaments of a joint, and *articular disease* resulting in distention of the capsule of the joint and elongation of the ligaments, are predisposing causes of dislocation.

Symptoms.—The most prominent symptoms of dislocation are: **Change in the Shape of the Articulation.**—This is caused by the change in the

position of the articulating surfaces of the bones, and tension or relaxation of the muscles in direct relation to the joint; thus, flattening of the shoulder is a marked symptom in dislocation of the shoulder, and in many cases of dislocation prominence of the displaced bone may alter materially the shape of the joint. **Change in the Length of the Limbs.**—This may consist either in shortening or in elongation. **Loss of Function.**—This is usually present, the dislocated part being no longer capable of executing the ordinary movements, being generally rigid, muscular contraction assisting in the fixation of the part. **Change in the Direction of the Limb.**—This is usually very marked in dislocation, and is produced by tension of the ligaments and muscles, as well as by contact of the displaced bone with an abnormal bony surface. This change is well demonstrated in dislocation of the head of the humerus and of the femur. **Crepitus.**—True crepitus cannot be elicited in cases of dislocation, but a moist crepitus can often be obtained which resembles the friction of a cartilaginous surface over bone or that obtained in the case of inflamed bursæ or tendons. *Swelling*, *pain*, and *discoloration* may also be present after dislocation, but these conditions do not differ materially from those observed after fracture.

Changes produced by Dislocation.—The immediate effects produced by dislocation are rupture of the capsular ligament, tearing of other ligaments, bruising or tearing of tendons or muscles adjacent to the joint, and injury of blood-vessels and nerves. In cases of dislocation following muscular relaxation, with elongation of the ligaments, displacement of the bone may occur without laceration of the ligaments. If the dislocation is promptly reduced, the rent in the capsule heals, and the parts are soon restored to their normal condition. If, however, the dislocation is not reduced, the articular surfaces of the bone undergo changes. In a ball-and-socket joint the ligaments become wasted, the head of the bone atrophies, the cartilages disappear, the articular cavity becoming filled up and its margins absorbed and flattened, and the head of the bone, if it rests upon a bony surface, forms for itself a new socket. If the head of the bone rests upon muscle, tendon, or fascia, the soft tissues undergo condensation, a cup-shaped cavity of fibrous tissue is formed, which is attached to the margins of the displaced bone, forming a new capsular ligament, and a synovia-like fluid is often secreted. (Fig. 476.) In the case of unreduced ginglymoid or hinge joints, the bony prominences are rounded off in time, the bones

Fig. 476.

New socket formed upon the dorsum of the ilium in unreduced dislocation of the femur. (After Agnew.)

accommodate themselves to their changed relations, and more or less motion may be regained, although the restoration of function is not usually so marked as in the case of ball-and-socket joints.

Prognosis.—The restoration of function after the reduction of recent dislocations is usually more or less complete, although it is not uncommon for stiffness or weakness of the joint to persist for some time. In many cases the occurrence of a dislocation predisposes to subsequent dislocation in the same joint upon exposure to violence, being due to weakness of the ligaments following the previous injury. An unreduced dislocation causes a certain amount of permanent disability, although in some joints a fair amount of restoration of function takes place after a time if the patient persists in using the part.

Treatment.—The indications in the treatment of dislocation are to restore the displaced parts to their normal position as soon as possible, and later to encourage the restoration of function in the joint.

Reduction of Dislocations.—The principal obstacles to the reduction of dislocations are the anatomical relations of the joint and muscular resistance; the latter may be manifested by reflex tonic contraction due to traumatic irritation, to voluntary contraction when the patient resists the efforts of the surgeon, and to passive muscular force from the stretching of the muscles across the bony prominences. The interposition of ligaments, nerves, blood-vessels, and fascia may sometimes act as a mechanical obstacle to the complete reduction of dislocations. **Anæsthesia.**—This is a most powerful aid in the reduction of dislocations; the active element of muscular spasm is entirely obliterated, and the general relaxation favors the manipulations necessary for the restoration of the displaced bone. An anæsthetic should, as a rule, be given before attempting the reduction of a dislocation, unless there is some contra-indication to its use, such as feebleness or pulmonary disease. **Manipulation.**—At present the most widely employed method of reducing dislocations is manipulation, which consists in the employment of those movements which relax the muscles, preventing the return of the displaced bone, and favor the contraction of muscles which may aid the reduction of the dislocation, at the same time the bone being moved in such a direction as to favor its replacement. The great majority of dislocations can be reduced by manipulation. In cases in which the reduction cannot be accomplished by manipulation, it may occasionally be necessary to resort to the application of force by extension and counter-extension, or to open incision. **Extension and Counter-Extension.**—This method of reduction is liable to do great violence to the soft parts in the neighborhood of the joint, causing laceration and rupture of muscles, veins, and blood-vessels, and even avulsion of limbs, and is now resorted to only in exceptional cases of long-standing dislocations. Extension or counter-extension may be employed by the hands of the surgeon or his assistants, or by the use of various mechanical devices, such as compound pulleys, the Spanish windlass, Jarvis's adjuster, or the Indian puzzle. The extending bands usually employed are made by folding sheets or towels into cravats and applying them by a noose knot or clove hitch at some distance from the displaced end of the bone.

Complicated Dislocations.—A serious complication of dislocation is the occurrence of a fracture in the same bone. In such cases an anæsthetic should be administered, and, if the shaft of the bone has been fractured, the fragments at the seat of fracture should be fixed with splints or a plaster of Paris dressing, while manipulations are made to reduce the dislocation. When this has been accomplished, an appropriate dressing should be applied for the fracture. Should the fracture occur so near the extremity of the bone that the fixation of the fragments is impossible, attempts to reduce the displaced bone should be made by manipulation, and when this has been accomplished the dressing for the fracture should be applied. Wounds of blood-vessels and nerves complicating dislocations should be treated upon general principles.

Compound Dislocations.—In this variety of dislocation the end or ends of the displaced bones are exposed to the air through a wound in the soft parts, and the existence of such a wound increases very materially the gravity of the injury. Compound dislocations may result from force applied from without lacerating the tissues and exposing the displaced bones in the wound, or more frequently from the luxated bone being driven through the soft parts and skin from within, and are much rarer than compound fractures. Hamilton, in a collection of one hundred and sixty-six dislocations, records eight only as compound. They are often complicated with a fracture of the ends of the displaced bones, or rupture of important blood-vessels and nerves.

Treatment.—Formerly compound dislocations of the larger joints were followed by so great a mortality under conservative methods of treatment that they were considered cases in which primary amputation was urgently indicated. Amputation is now rarely employed, except in cases complicated by laceration of the soft parts and of important blood-vessels, as it is often possible to save the limb and preserve the function of the joint.

The treatment in any compound dislocation depends largely upon the amount of laceration of the soft parts, the condition of the large blood-vessels at or near the seat of injury, and the existence of a fracture at the ends of the displaced bones. In a compound dislocation in which the injury to the blood-vessels and soft parts or bone is not extensive, the protruding bone or bones, as well as the wound, should be carefully sterilized, the reduction accomplished, the wound drained and dressed with a copious antiseptic dressing, and the part put at rest upon a splint or fixed by a plaster of Paris dressing. In the smaller articulations, such as those of the fingers and toes, the results of this method of treatment are usually satisfactory. In the case of compound dislocations of the larger joints, some diversity of opinion exists among surgeons as to whether it is wiser to reduce the dislocation and close the wound, or to excise, either partially or completely, the ends of the displaced bones. We think the judgment of most surgeons now is in favor of sterilization of the ends of the bones and the wound, of reducing the dislocation and introducing drainage, and, after applying an antiseptic dressing, fixing the parts by splints or the plaster of Paris dressing. *Tenotomy* of resisting tendons will often facilitate the reduction of compound dislocations, and subsequently favors immobilization of the parts. In compound dislocations where there is a fracture of

the ends of one or both bones, excision, either partial or complete, should be practised. After excision the wound should be drained, and the part dressed and fixed upon a splint, and at the end of ten days or two weeks, when the wound has healed, passive motion should be carefully employed, to prevent bony ankylosis, except in the case of the knee. We have seen most satisfactory results follow excision of the shoulder-, elbow-, and ankle-joints in such cases.

SPECIAL DISLOCATIONS.

DISLOCATIONS OF THE LOWER JAW.

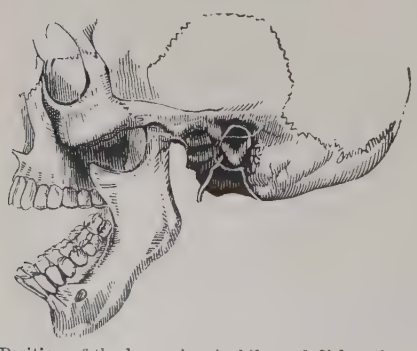
Dislocation of the lower jaw is a comparatively rare accident, constituting about four per cent. of all dislocations. It is more common in females than in males, and is an extremely rare injury in childhood. This dislocation may be bilateral, unilateral, or incomplete.

Causes.—A predisposing cause of this dislocation may be a shallow glenoid cavity, the articular eminences being unusually low. Relaxation of the ligaments or weakness of the muscles of mastication, as is sometimes observed in feeble subjects, may also predispose to this injury. The causes which produce this injury are violence from falls received upon the chin, unusually wide opening of the mouth, biting upon hard substances, and dental operations.

This displacement is produced when the lower jaw is strongly depressed, the condyles moving forward and carrying with them the interarticular cartilages upon the articular eminences. When the condyles of the jaw are in this position, if the jaw is still further depressed, the condyles break through the front of the capsular ligament, and are pulled from their articular eminences by the action of the external pterygoid, masseter, and temporal muscles. (Fig. 477.)

Bilateral Dislocation.—When both condyles of the inferior maxilla are removed from their articulating cavities the front teeth will be found separated for an inch or more; the mouth remains open,

Fig. 477.



Position of the lower jaw in bilateral dislocation. (Agnew.)

Fig. 478.

Bilateral dislocation of the lower jaw.

and the line of the teeth in the lower jaw is in advance of that of the upper. The chin is unduly prominent (Fig. 478), the jaw is fixed, and pain is usually

a prominent symptom. A slight prominence can usually be felt immediately behind the malar bone, which is caused by the coronoid process and the tendon of the temporal muscle.

Unilateral Dislocation.—In this dislocation one condyle only is displaced, in consequence of which the lower jaw is carried towards the opposite or uninjured side, giving the chin a twisted appearance; the jaws are somewhat separated, the mouth is held partially open and the jaw is fixed, and a depression is felt in front of the ear on the side of displacement and a prominence on the sound side. The incisor teeth of the lower jaw on the sound side are external to those of the upper jaw.

Subluxation.—This affection is often habitual, and the symptoms are sudden immobility of the jaw, coming on while chewing or biting upon hard substances, slight separation of the incisor teeth, and inability to approximate the teeth. It is caused by the interarticular cartilages slipping behind the condyles and fixing them upon the articular eminences.

Diagnosis.—Dislocation of the jaw may be confounded with a fracture of the neck of the condyle. In fracture there is mobility, with a prominence of the fragment below the zygomatic line, and the chin falls towards the injured side, while in dislocation of one condyle there is immobility and the chin inclines to the opposite side.

Treatment.—The patient should be seated in a chair or placed upon a bed, and an assistant should support the head, while the surgeon standing in front of the patient, having protected his thumbs by wrapping them with a piece of muslin, passes them into the mouth and backward until they rest upon the molar teeth of each side. The jaw should first be pressed downward, then, by elevating the anterior portion of the bone, the condyles will be drawn into position by the action of the temporal and masseter muscles. (Fig. 479.) The condyles usually slip into place with an audible sound, and as soon as the surgeon feels that the jaw has changed its position he should remove his thumbs to prevent them from being bitten. In cases of dislocations of some standing, enough force may not be obtained by the use of the thumbs, and wooden levers may be employed to depress the jaw at the same time that the pressure is made beneath the chin. Dislocations of the jaw of several weeks' standing have been reduced by simple manipulation. If it is found impossible or difficult to reduce a dislocation of the jaw by reason of the muscular rigidity and contraction, it is well to anæsthetize the patient, when it can usually be reduced without much difficulty. *Subluxation* of the jaw, if not reduced by the patient by muscular action, can usually be reduced by introducing a narrow wooden wedge between the teeth and prying the jaws apart, or the coronoid processes may be pressed downward and backward with the fingers. After the reduction of dislocation of the lower jaw, a

Fig. 479.

Reduction of dislocation of the lower jaw.

Barton's bandage should be applied to secure the lower jaw in contact with the upper for a week or ten days. The patient should be careful in making movements of the jaw until the rent in the capsular ligament is healed, for fear of reproducing the displacement.

Noisy Movements of the Temporo-Maxillary Articulation.—These consist in snapping sounds heard during the movements of the jaw in chewing, and are produced by the condyles of the jaw slipping forward upon their articular eminences when the jaw is depressed, and then suddenly slipping backward during its elevation. The condition is probably due to relaxation of the ligaments of the articulation, and seems to predispose to dislocation. For the relief of this condition the injection of a few drops of absolute alcohol into the ligaments has been recommended, and has been practised in some cases with success.

Congenital dislocations of the lower jaw are extremely rare. A case has been reported by Mr. R. W. Smith in which there was very imperfect development of the glenoid cavity, interarticular cartilages, ligaments, and muscles upon the affected side.

DISLOCATIONS OF THE STERNUM.

Dislocation of the bones of the sternum from each other is a rare injury, and may consist in a separation of the body of the bone from the manubrium, or of the ensiform process from the body.

Dislocation of the Body of the Sternum from the Manubrium.—This dislocation may be produced by direct force or by forcible extension of the body. The displacement may be forward or backward. When resulting from direct force applied to the body of the sternum, this is usually displaced backward and the manubrium projects forward, or the manubrium may be driven backward as the result of direct force and occupy a position behind the body of the bone. The costal cartilages usually retain their attachments to the manubrium. Displacements of the manubrium from the body of the bone may be associated with fractures of the ribs or of the costal cartilages. **Symptoms.**—The usual symptoms of this dislocation are interference with the respiration and a projection upon the anterior surface of the sternum, due to either the lower end of the manubrium or the upper end of the body of the bone, according as the fragments are displaced backward or forward. The gravity of this accident depends largely upon its association with injury of the intrathoracic viscera. **Treatment.**—Attempts should be made to reduce the displacement in cases of dislocation of the manubrium or the body of the bone, but are not always followed by success. An anæsthetic should be administered if the patient's condition will permit of it, and flexion or extension of the trunk should be made, with direct pressure over the projecting bone. If it is found impossible to reduce the deformity no violent attempts should be made, as patients have recovered with marked deformity, and have subsequently suffered little inconvenience from it; but if the displacement causes great discomfort the displaced bone should be exposed by incision and elevated.

Dislocation of the Ensiform Process.—This is an injury which is occasionally produced by blows or kicks upon the epigastrium. The

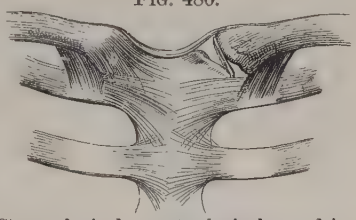
injury may be followed by severe pain in the region of the stomach, and difficulty in respiration and occasionally vomiting, which may persist for some time. **Treatment.**—Reduction may be accomplished by manipulation, which consists in passing the fingers below the process and attempting to push it forward, or by making a puncture in the skin, introducing a tenaculum into the cartilage, and drawing it forward. If the deformity recurs and is accompanied by troublesome symptoms, excision should be resorted to.

DISLOCATIONS OF THE CLAVICLE.

Dislocations of the clavicle may occur at the sternal or at the acromial end of the bone.

Dislocation of the Sternal End of the Clavicle.—The sterno-clavicular articulation possesses an interarticular fibro-cartilage attached below to the first costal cartilage and above to the clavicle. The articulation is surrounded by a capsular ligament, strengthened anteriorly and posteriorly by the sterno-clavicular and costo-clavicular ligaments. (Fig. 480.) Sterno-clavicular dislocations of the clavicle may be forward, backward, or upward.

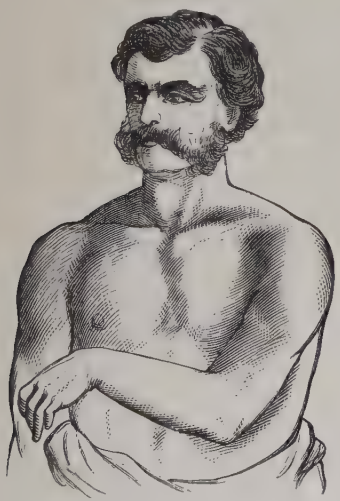
Fig. 480.



Sterno-clavicular, costo-clavicular, and inter-clavicular ligaments. (Agnew.)

Forward Dislocation.—This is a frequent dislocation of the clavicle, in which the bone takes a position in front of and in contact with the upper extremity of the sternum, and is caused by force applied to the shoulder, forcing it violently backward. **Symptoms.**—The most prominent symptoms are the presence of a swelling in front of the upper part of the sternum, a tense ridge corresponding to the clavicular origin of the sterno-cleido-mastoid muscle, a diminished space between the acromion process of the scapula and the sternum, and a sinking downward and inward of the shoulder. (Fig. 481.) Pain is usually present upon motion of the arm, and the movements of the arm are much restricted. Incomplete dislocation of the sternal end of the clavicle may occur, and is accompanied by the same symptoms in a lesser degree. This dislocation may also be associated with a fracture of the edge of the clavicle or of the edge of the articular surface of the sternum. **Treatment.**—Reduction is effected by drawing the shoulders backward and at the same time making pressure upon the end of the clavicle. It is often easy by this manipulation to reduce the deformity, but it is difficult to maintain the reduction. The dressing consists in a compress applied over the replaced head of the bone,

Fig. 481.



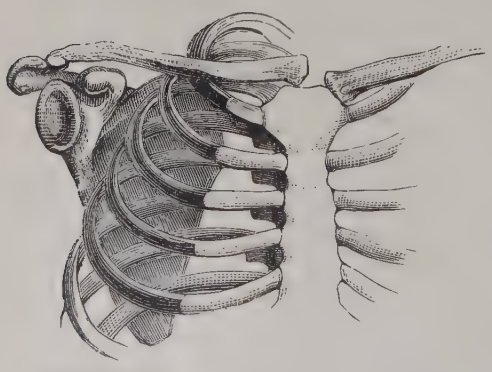
Deformity in anterior dislocation of the sternal end of the clavicle. (Agnew.)

with the shoulders held backward by a figure-of-eight bandage, or the patient may be placed in bed in the recumbent posture and a compress held over the replaced end of the bone by means of a bandage or strips of adhesive plaster. When the patient is allowed to get about, to prevent a reproduction of the deformity the arm should be fixed to the side of the body by means of a Velpeau's bandage, fixation dressings being maintained in this dislocation for six or eight weeks, until adhesions have occurred at the seat of injury. In spite of the most careful treatment, more or less permanent deformity is often unavoidable. Notwithstanding this, however, the functional results obtained are usually satisfactory.

Backward Dislocation.—This may be produced by force applied directly to the anterior portion of the clavicle, near the sternal extremity, or indirectly by force received upon the posterior and outer aspects of the shoulder; the displaced end of the clavicle may occupy a position below and behind the top of the sternum or slightly above it. **Symptoms.**—A prominence may be felt just behind or above the top of the sternum; the shoulder drops forward and inward, and the displaced bone may press upon the trachea or œsophagus and cause dyspnœa or dysphagia. **Treatment.**—Reduction is effected by standing behind the patient and drawing the shoulders upward and backward, when the bone will slip forward into its normal position. After the deformity has been reduced a compress should be placed over the articulation and held in position by adhesive straps, and the patient should be placed in bed upon a firm mattress; if, however, the patient cannot stay in bed, it is well to apply a compress and a posterior figure-of-eight bandage to the shoulders, to draw them backward so as to prevent recurrence of the displacement. The dressings should be retained from six to eight weeks.

Dislocation Upward.—This dislocation is a rare one, and usually results from indirect force applied to the shoulder or the acromial end of the clavicle. **Symptoms.**—The most marked symptoms are a prominence above the top of the sternum (Fig. 482), depression of the shoulder, pain, and tenseness of the sternal origin of the sterno-cleido-mastoid muscle, which is stretched over the end of the displaced bone. **Treatment.**—In reducing this displacement the arm should be drawn upward and outward, while the head of the clavicle is pressed downward into its articular cavity. A compress should be applied over the seat of injury and fastened in position by a roller bandage or by adhesive straps. If it is found impossible to maintain the reduction, the displaced bone should be exposed by an incision and secured in its normal position by strong wire sutures.

Fig. 482.

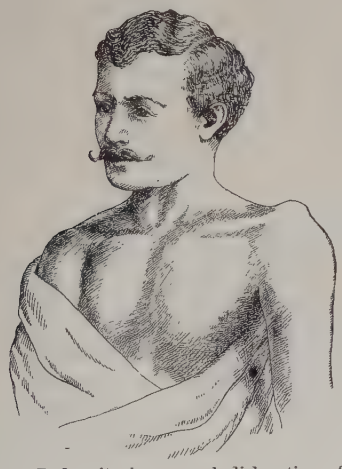


Upward dislocation of the sternal end of the clavicle. (Agnew.)

Dislocations of the Acromial End of the Clavicle.—Dislocations of the acromial end of the clavicle are sometimes described as dislocations of the scapula. There are three varieties: one in which the end of the clavicle is displaced upward from the acromion process; another in which the end of the clavicle is below the acromion process; and one in which the clavicle takes a position below the acromion and coracoid processes. The first variety of acromial dislocation of the clavicle is that most frequently seen. Dislocations of the acromial end usually result from force applied to the clavicle or to the acromion process of the scapula.

Dislocation Upward.—This is marked by a projection above the acromion process, dropping of the shoulder, and more or less disability in the use of the arm. Examination with the fingers will reveal the displaced acromial end above the acromion process. (Fig. 483.) **Treatment.**—The reduction of this displacement is usually not a matter of difficulty, and is accomplished by pushing the head of the humerus upward, at the same time making downward or slightly lateral pressure upon the displaced acromial end of the clavicle. Although the reduction can be accomplished with ease, the greatest difficulty is often experienced in maintaining it. A compress should be placed over the end of the clavicle, and the arm should be

Fig. 483.



Deformity in upward dislocation of the acromial end of the clavicle. (After Agnew.)

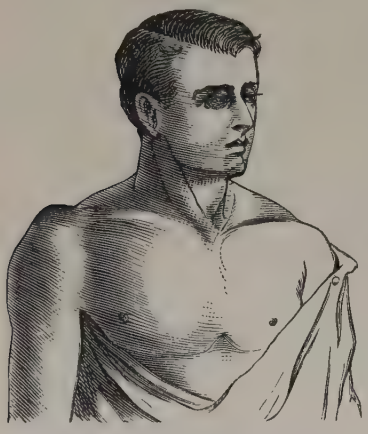
Fig. 484.

Stimson's dressing for upward dislocation of the acromial end of the clavicle.

fastened to the side by a Velpeau's bandage. A very satisfactory method of retaining the end of the bone in place has been recommended by Stimson, consisting in applying a long strip of adhesive plaster three inches wide, the centre being placed over the flexed elbow and its ends carried up in front of and behind the arm, crossing over the end of the clavicle and being secured on the front and back of the chest respectively, while the bone is held in place by pressure upon the clavicle and the elbow. For additional security the forearm may be supported in a sling and the arm bound to the side of the chest. (Fig. 484.) In this dislocation, wiring the dislocated

end of the bone in place has been practised with advantage. We therefore think it is well in persistent cases of this dislocation to cut down upon and expose the displaced bone and secure it in its normal position by heavy wire sutures.

Fig. 485.



Deformity in downward dislocation of the acromial end of the clavicle. (Agnew.)

Dislocation Downward.—This is a comparatively rare accident, the acromial end of the clavicle passing between the acromion and coracoid processes. **Symptoms.**—The acromion process is abnormally prominent, and a groove or gutter can be felt along its inner border; more or less disability of the arm is present, and the displaced end of the clavicle may be felt under the acromion process. (Fig. 485.) **Treatment.**—This displacement is reduced by manipulation, the bone being fixed in place after reduction by the application of a compress and adhesive straps or by wire sutures, and by securing the arm to the side by a Velpeau bandage.

Subcoracoid Dislocation of the Clavicle.—This displacement is extremely rare, but a few cases have been reported. It is said to result from the shoulder being forced upward, outward, and backward, while at the same time the acromion process of the clavicle is driven downward. The most marked symptoms are unusual prominence of the acromion and coracoid processes, pain and restricted motion of the arm, and an increase in the distance between the sternum and the summit of the shoulder. **Treatment.**—To reduce this displacement the arm should be flexed and brought to the side and carried forcibly upward, inward, and backward to relax the clavicular portion of the pectoralis major muscle. The clavicle should be grasped and disengaged from its position below the coracoid process and pressed back into its proper position. After reduction a Velpeau's bandage should be applied and the dressing retained from six to eight weeks.

Simultaneous Dislocation of Both Ends of the Clavicle.—This very unusual dislocation has occasionally been observed, and is the result of extreme violence, in which the shoulder is pressed inward, the sternal end being usually dislocated forward and the acromial end upward. **Treatment.**—Reduction may be accomplished by drawing the shoulder strongly backward and making pressure over both the sternal and clavicular ends of the bone at the same time; a compress should be placed over each end of the bone and secured in position by adhesive straps or bandages, and the arm secured to the side. The dressings should be retained for six or eight weeks. The results following the reduction of simultaneous dislocation of both ends of the clavicle have been quite satisfactory.

Dislocation of the Inferior Angle of the Scapula.—This dislocation occurs when the latissimus dorsi muscle, which passes over the lower angle of the scapula, slips beneath the lower extremity of the bone. The

accident occasionally occurs in children from lifting them by one arm. **Symptoms.**—The displacement may be recognized by a marked projection of the lower angle of the scapula, which increases when the arm is drawn forward; pain and disability of the arm may also be present. To reduce this deformity the muscle should be relaxed by carrying the arm well backward, and when in this position manipulation with the fingers should be made to replace the muscle. It may be found impossible to reduce the deformity in these cases.

DISLOCATIONS OF THE SHOULDER-JOINT.

Dislocation of this joint occurs more frequently than of any other joint in the body, forming a little over fifty per cent. of all dislocations. This fact is due to the great extent of movement permitted by the scapulo-humeral articulation, the shape of the glenoid cavity, and the great leverage due to the length of the upper extremity.

Causes.—A dislocation of the shoulder may result from indirect violence, such as falls upon the elbow or hand, or from direct violence, as a severe blow upon the anterior or posterior part of the shoulder, or from muscular action.

Varieties.—The most frequent dislocations of the shoulder-joint are (1) dislocation of the head of the bone downward and slightly inward, *subglenoid;* (2) forward, *subcoracoid;* (3) *subclavicular;* (4) backward on the dorsum of the scapula, *subspinous.* Anomalous dislocations occasionally occur, either from force acting in a particular way or applied after one of the ordinary dislocations has occurred. Among the anomalous dislocations may be mentioned the *supra-acromial* and the vertical dislocation of the arm above the head, *luxatio erecta.*

Subglenoid Dislocation.—In this dislocation the capsular ligament is extensively torn on its lower surface, and the head of the humerus slips through it and takes a position on the anterior border of the scapula immediately below the glenoid cavity. (Fig. 486.) The head of the bone rests between the tendon of the triceps and subscapular muscles. The axillary blood-vessels and nerves may suffer more or less from pressure, and the muscles surrounding the articulation also may be injured. It is not unusual in this dislocation for the deltoid muscle to be paralyzed from damage done to the circumflex nerve. The deformity in this dislocation is well shown in Fig. 487.

Causes.—This dislocation may follow a fall or a blow upon the anterior surface of the shoulder, or may be produced by force which drags the arm over the head. Violent muscular contraction may also produce it.

Subcoracoid Dislocation.—In this dislocation, which is the most common of the shoulder dislocations, the anterior surface of the capsular ligament is lacerated and the head of the bone takes a position upon the inner surface of the neck of the scapula below the coracoid process. (Fig. 488.) The deformity in this dislocation is shown in Fig. 489.

Subclavicular Dislocation.—Here the head of the bone rests upon the side of the chest below the clavicle (Fig. 490), and is covered by the pectoralis major and minor muscles. The supraspinatus and infraspinatus muscles and the portion of the deltoid which arises from the acromion

process of the spine of the scapula, with the inner fibres of the coracobrachialis muscle and the short and long head of the biceps, are put upon the stretch. The axillary vessels and nerves are often severely pressed upon.

Causes.—Subcoracoid and subclavicular dislocations may arise from any force which carries the arm violently backward and upward, pressing the head of the humerus against the inner part of the capsular ligament. They also result from blows or falls upon the outer surface of the shoulder.

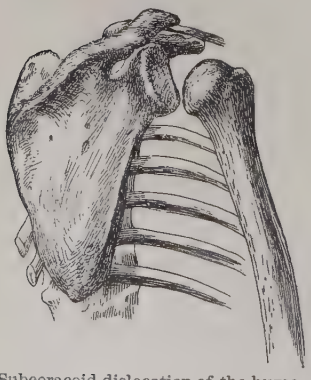
Fig. 486.

Subglenoid dislocation of the humerus. (After Agnew.)

Fig. 487.

Deformity in a recent subglenoid dislocation of the humerus.

Fig. 488.



Subcoracoid dislocation of the humerus. (After Agnew.)

Fig. 489.

Deformity in a recent subcoracoid dislocation of the humerus.

Subspinous Dislocation.—In this dislocation the head of the humerus rests on the dorsum of the scapula behind the glenoid cavity and immediately below the spine of the scapula. (Fig. 491.)

Causes.—Subspinous dislocations are produced by force applied to the anterior surface of the shoulder.

Fig. 490.

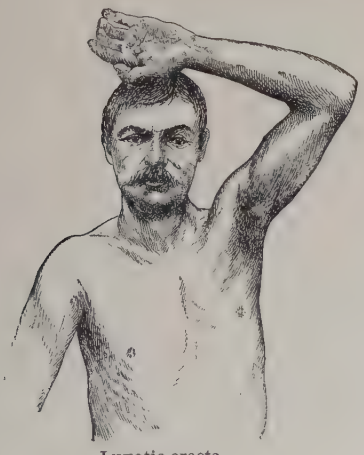
Subclavicular dislocation of the humerus. (After Agnew.)

Fig. 491.

Subspinous dislocation of the humerus. (Agnew.)

Luxatio Erecta.—Among the rare dislocations of the head of the humerus is that known as luxatio erecta. (Fig. 492.) In this dislocation the arm is held vertically, the forearm resting on the top of the head and being held there by the patient to escape the pain caused by lowering it.

Fig. 492.



Luxatio erecta.

Fig. 493.

Supracoracoid dislocation. (Hamilton.)

Subluxation of the Head of the Humerus.—A condition described as subluxation of the head of the humerus is one which is distinguished by a depression beneath the acromion upon the posterior aspect of the joint, and a well-rounded prominence formed by the head of the humerus lying in contact with the coracoid process. This injury should rather be described as a *rupture of the long tendon of the biceps muscle*, in consequence of which the supraspinatus muscle draws the bone out of its normal position.

Supracoracoid Dislocation.—A few cases of dislocation of the head of the humerus have occurred in which the bone occupied a position above the coracoid process. The head of the humerus lies in the interval between the acromion and coracoid processes, in front of the clavicle and usually above its level. (Fig. 493.) The arm occupies a position by the side of the body, and is directed rather backward. Reduction is effected by traction upon the arm and by elevation of the elbow.

Symptoms.—The signs of dislocation of the head of the humerus which are common to all varieties are an alteration in the shape of the shoulder; the rotundity of the shoulder disappears, and it becomes flattened; the acromion process becomes abnormally prominent, and beneath this is a marked depression in which the fingers can readily be sunk. The elbow stands off from the body, except in subspinous dislocation, and it will be found impossible to place the hand of the injured limb upon the shoulder of the sound side while the arm rests against the chest. This is the test pointed out by Dugas, and we consider it a most valuable one. There is also marked restriction of the movements of the shoulder-joint, and the displaced head of the bone can be located by the fingers. Pain is more marked in some varieties of shoulder dislocation than in others, and is often accompanied by numbness of the fingers in consequence of pressure upon the axillary nerves.

Diagnosis.—The diagnosis of dislocation of the head of the humerus is not difficult if the patient is seen soon after the injury; if, however, much swelling has occurred, it is in many cases often made with difficulty. Therefore in obscure cases it is wise to administer an anæsthetic and make a careful and methodical examination of the joint to determine the presence of dislocation or of fracture of the neck of the humerus, or to demonstrate the association of these two injuries. In a case of injury of the shoulder-joint, in which the arm rests against the side of the body and can be moved freely, if *Dugas's test* can also be made, and if the fingers cannot be thrust into the space beneath the acromion process, the possibility of dislocation can be dismissed. Dislocation of the head of the humerus may be confounded with fracture of the neck of the humerus, of the neck of the scapula, or of the acromion. In all these cases there will be preternatural mobility, crepitus, and ease of reduction, with a tendency to a recurrence of the deformity as soon as the limb is released from the reducing force. In dislocation the acromion stands out prominently, the shoulder is flattened, the arm stands out from the side of the body, the fingers can be thrust in a space under the acromion, the head of the bone can usually be felt in an abnormal position, and there is pronounced rigidity of the arm. Fractures of the surgical neck of the humerus or separation of the upper epiphysis may present a prominence in front of the shoulder, but the change in the shape of the shoulder, the position of the arm, and the mobility are entirely different from that observed in cases of dislocation.

Treatment.—The principal methods practised in the reduction of dislocations of the head of the humerus are manipulation, and extension and counter-extension.

Reduction by Manipulation.—This consists in placing the arm in such

a position that the muscles inserted into the upper extremity of the humerus which are rendered tense by the displacement will be relaxed, and the head of the bone will be moved into its normal position. Reduction of the many dislocations of the head of the humerus may be accomplished without the use of an anæsthetic, but the manipulations are painful, and the muscular resistance is often so marked that it is wise to administer an anæsthetic. In reducing a dislocation of the humerus by manipulation, the patient should be placed in the recumbent position and anæsthetized, and the forearm flexed upon the arm, to relax the long head of the biceps muscle; the arm is next grasped at the elbow and abducted, and raised so as to bring it to the side of the patient's head, thus relaxing the deltoid and supraspinatus muscles. The surgeon should next place the fingers of the other hand upon the head of the humerus, which can be felt under the skin in the axilla, and as the arm is drawn outward and brought to a right angle with the chest the head of the bone is lifted into its socket.

Fig. 494.

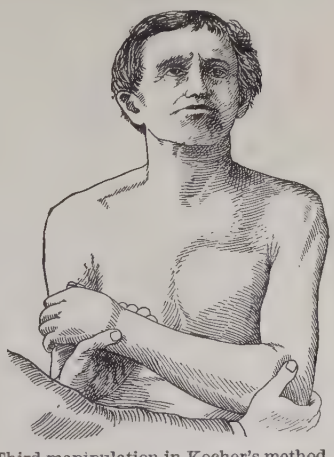
Kocher's method of reducing dislocation of the shoulder: first manipulation.

Kocher's Method.—In reducing a dislocation of the head of the humerus by this method the elbow is flexed at a right angle and pressed closely against the side; the forearm is then turned as far as possible away from the trunk, causing external rotation of the arm. (Fig. 494.) If the head of the humerus does not roll outward in front of and below the acromion during this manipulation, the attempt will fail. While the external rotation is

Fig. 495.

Second manipulation in Kocher's method.

Fig. 496.

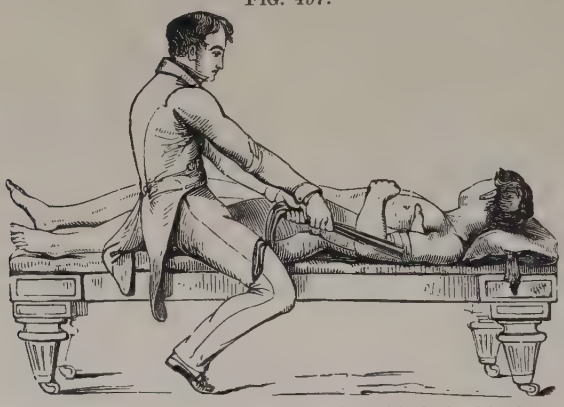


Third manipulation in Kocher's method.

maintained the elbow should be carried well forward and upward (Fig. 495); the arm should next be rotated inward, and the elbow lowered. (Fig. 496.) Sometimes it may be of use to have an assistant press the head outward with the fingers or by a band in the axilla during the latter manipulation.

Reduction by Extension and Counter-Extension.—The reduction of dislocation of the humerus by extension and counter-extension may also be practised. This method consists in making counter-extension by placing the heel in the axilla while traction is made upon the arm downward from

Fig. 497.



Reduction by extension and counter-extension with the heel in the axilla.

the arm or the forearm by the hands or an extending band. (Fig. 497.) The principal risk in this method is of injury of the axillary vessels.

Mothe's Method.—This method of extension and counter-extension is also used in the reduction of dislocations of the head of the humerus. The patient being in the recumbent position on a table or a bed, the surgeon takes hold of the arm on the injured side above the elbow with one hand, and places the other hand upon the top of the shoulder in order to fix the

Fig. 498.

Mothe's method of reduction of dislocation of the humerus.

scapula, making strong traction upon the arm. (Fig. 498.) With this manipulation the head of the bone may be slipped into its socket, but if this does not occur, while the extension is maintained the limb should be rotated

and carried a little off from the body, and an assistant should press the head of the bone upward and outward towards the articulating cavity, while the arm, still strongly extended as before, is brought down to the side. The reduction of luxatio erecta is usually easily accomplished by traction upward without changing the attitude of the limb until the head has been drawn into its socket.

After-Treatment.—After reducing any form of dislocation of the shoulder, the arm should be fixed against the side of the body and the forearm carried in a sling for a week or ten days, or a Velpeau's bandage may be applied to secure fixation of the shoulder-joint. At the expiration of ten days the dressings should be removed and the patient should carry the arm in a sling, and be encouraged to use it, being careful not to make any violent motions of the shoulder-joint.

COMPLICATIONS OF DISLOCATIONS OF THE HUMERUS.

Old Dislocations of the Humerus.—Old dislocations of the humerus have been reduced after months or even years, but, as a rule, the older the dislocation the greater the difficulty in its reduction, and the manipulations may be accompanied by risk of injury to the axillary vessels; this is particularly the case if marked inflammatory action followed the original displacement of the bone, and if adhesions are present between the head of the bone and the vessels in the axilla. If a patient has had the head of the humerus out for several years, does not suffer from pain, and has regained a certain amount of motion of the arm from the formation of a new articulation, it would be unwise to make attempts to replace it.

In unreduced dislocations of recent occurrence attempts should always be made to replace the bone. To accomplish reduction the patient should be thoroughly anæsthetized, and the surgeon should seize the arm at the elbow and first rotate the head of the bone freely to break up any adhesions which may exist. After the surgeon is assured that the adhesions have been thoroughly separated, he should endeavor to reduce the dislocation by manipulation or by Kocher's method. If these fail, he should next try some of the various methods by extension and counter-extension. The principal risks in the reduction of old dislocations of the humerus are rupture of the axillary artery or vein, injury of the axillary plexus of nerves, and fracture of the neck or head of the humerus.

Rupture of the Axillary Artery.—This accident has occurred during the reduction of old dislocations of the humerus. The signs which indicate this accident are a rapidly developed swelling in the axilla and under the pectoral muscles, absence of the pulse at the wrist, pallor of the face, and in some instances syncope. In such a case pressure should be applied to the subclavian vessel, and the axillary artery should be cut down upon and secured by ligatures applied on each side of the rupture. **Rupture of the Axillary Vein.**—This accident has also occurred during attempts to reduce old dislocations of the humerus. It is to be distinguished from rupture of the axillary artery by the facts that the patient does not exhibit the constitutional symptoms of loss of blood in so marked a degree as in cases of rupture of the artery, and that the radial pulse is present. If this accident

occurs during manipulation, a compress should be placed in the axilla and the arm bound firmly to the side; it is not unusual, although a large amount of blood may have escaped, to have the hemorrhage thus controlled, and for the patient to go on to recovery. If this fails, the vein should be ligated. **Injury of Nerves.**—The axillary plexus of nerves may be damaged in forcible attempts to reduce old dislocations of the humerus, the injury being followed by paralysis of the arm. **Fracture.**—Fracture of the neck, head, or shaft of the humerus has occurred in the manipulations practised to reduce old dislocations of the humerus. If fracture occurs high up in the bone, no further attempts can be made to restore the dislocation, and the patient should be encouraged to use the arm, with the idea of a false joint forming at the seat of fracture, giving him a wider range of motion.

Dislocation of the Humerus with Fracture of the Neck of the Humerus.—These two accidents may result from the application of the same force. The diagnosis of this injury can usually be made by discovering that the head of the bone occupies an abnormal position and is not affected by movements of the arm; crepitus may also be elicited. The deformity of the shoulder is that of dislocation, but the arm is movable and the elbow can be brought into contact with the chest.

Treatment.—The patient should be anæsthetized, and the head of the bone pressed back into the glenoid cavity with the fingers, after which the fracture should be dressed in the manner described for the treatment of fractures of the surgical neck of the humerus. If it is found impossible to reduce the displaced head of the bone, it should be exposed by incision, the capsule freely incised, and after reduction of the head of the bone the fragments wired. If this is not possible, excision of the head of the bone should be practised.

Compound Dislocation of the Humerus.—In some cases of dislocation of the humerus the head of the bone has been driven through the soft parts, causing a compound dislocation. If the vessels remain uninjured, the skin and the exposed head of the bone should be thoroughly sterilized, the bone reduced, and the wound closed. If the head of the bone, however, has been fractured, it is safer to excise it before attempting reduction. In cases of compound dislocation of the head of the humerus complicated with laceration of the axillary artery, amputation at the shoulder-joint would probably be required, although even here conservative treatment might be attempted, the vessel being tied, the dislocated bone replaced, and the wound dressed with a copious antiseptic dressing.

Simultaneous Dislocation of the Heads of both Humeri.—This injury is occasionally seen, and has resulted from falling upon the hands when the arms were outstretched The reduction is accomplished in the same manner as in single dislocations.

Congenital Dislocations of the Humerus.—Congenital dislocations of the humerus have occasionally been met with in association with malformations of other joints. The variety of dislocation is either subcoracoid or subspinous. The symptoms of this dislocation are similar to those observed following subcoracoid and subspinous dislocations. In congenital

dislocations of the head of the humerus the upper arm is usually very markedly atrophied, while the forearm retains its natural size. These dislocations have not furnished very satisfactory results as regards treatment. One case has been reported in which the humerus was permanently restored to its articulating cavity after repeated manipulations. Erb's paralysis has sometimes been mistaken for this injury.

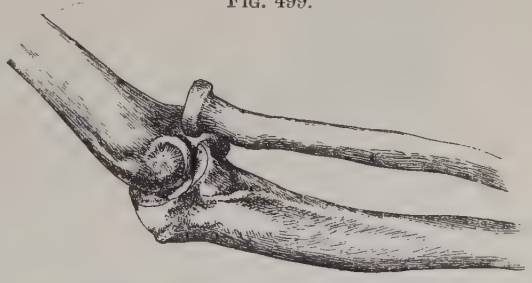
DISLOCATIONS OF THE BONES OF THE FOREARM.

Dislocations of the bones of the forearm are most common during early life, and present a number of different displacements: (1) the head of the radius may be dislocated from the humerus; (2) the ulna may be dislocated from the humerus; (3) both radius and ulna may be dislocated from the humerus; (4) the inferior extremity of the ulna may be dislocated from the radius.

Radio-Humeral Dislocations.—The head of the radius may be detached from the sigmoid cavity of the ulna, and be displaced forward, backward, or outward. In these dislocations the lateral and annular ligaments are torn, and the head of the bone rests in front of, behind, or external to the external condyle of the humerus. Displacement of the head of the radius is not an infrequent accident, and is quite often overlooked.

Forward Dislocation of the Head of the Radius.—This is the most common dislocation of the head of the radius, and is usually produced by a fall upon the hand while the latter is in a state of pronation, or by force applied to the side of the elbow. **Symptoms.**—The radial side of the forearm is shortened and inclined outward, and a depression exists immediately below the external condyle of the humerus. The head of the radius can be felt in front of the elbow, and may be recognized by placing the thumb upon it and pronating and supinating the forearm. (Fig. 499.) The biceps muscle is relaxed, the forearm cannot be thoroughly extended, and flexion is interfered with by the displaced head of the bone being arrested against the lower portion of the humerus.

FIG. 499.



Forward dislocation of the head of the radius. (After Agnew.)

Treatment.—To reduce this dislocation the forearm should be flexed upon the arm, to relax the biceps muscle, extension being made from the hand and counter-extension from the arm; the surgeon then presses the head of the bone downward and outward towards the lesser sigmoid cavity of the ulna, and at the same time pronates the hand. The displacement can usually be reduced without much difficulty, but is often reproduced upon making flexion or extension of the arm. After reduction the arm should be secured in the flexed position by the application of a well-padded anterior angular

splint, with the addition of a compress over the anterior surface of the head of the radius. This splint should be changed at intervals of two or three days and worn for several weeks. After removing the splint the patient should be cautioned against making violent flexion, pronation, or supination of the forearm, as it is often a matter of some weeks before the repair of the capsular ligament is sufficiently firm to prevent the recurrence of the displacement. In unreduced forward dislocations of the head of the radius patients often regain very fair use of the arm, but may have some limitation in flexion of the forearm upon the arm. If the displacement causes pain or interferes very decidedly with the use of the arm, attempts should be made to reduce it; if this cannot be done, the procedure which offers the best result as regards increased usefulness of the arm is excision of the head of the radius, a section of the bone being made just above the insertion of the tendon of the biceps muscle. We have seen very satisfactory results follow this procedure in these cases.

Backward Dislocation of the Head of the Radius.—This is a rare form of dislocation, in which the head of the radius escapes through the posterior portion of the capsular ligament and rests behind the external condyle of the humerus. (Fig. 500.) It may result from force applied to the front of the head of the radius, or may be caused by a fall upon the hand when the bones of the forearm are in extreme pronation. **Symptoms.**—In this dislocation the forearm is slightly flexed, the hand is pronated, supination is impossible, a depression can be felt below the external condyle of the humerus, and the head of the radius can be located behind the condyle; flexion and extension of the forearm are also much diminished. **Treatment.**—The forearm should be flexed, and an assistant makes counter-extension from the arm while the surgeon makes extension from the hand, and by supinating the forearm and pressing the head of the bone forward towards the articular cavity the reduction can usually be accomplished. After reduction the forearm and arm should be placed on an obtuse-angled splint, which should be worn for several weeks.

FIG. 500.

Backward dislocation of the head of the radius. (After Agnew.)

Outward Dislocation of the Head of the Radius.—This is an extremely rare dislocation: the head of the bone rests upon the epicondyloid ridge. The symptoms are a prominence above and in front of the external condyle of the humerus, flexion of the forearm in a position between pronation and supination, and impairment in the movements of flexion and extension of the forearm. **Treatment.**—This can be accomplished by making extension and counter-extension when the arm is moderately flexed, at the same time pressing the head of the bone downward and forward. The limb should be fixed upon an angular splint, as after reduction of other forms of radial displacement.

Dislocation of the Ulna from the Humerus.—This consists in a posterior displacement of the ulna upon the humerus, the radius maintaining its normal position, the coronoid process sliding backward to the olecranon fossa, or resting upon the posterior face of the internal condyle of the humerus. (Fig. 501.) The treatment of this dislocation is similar to that for dislocation of both bones of the forearm.

Fig. 501.

Posterior dislocation of the ulna. (After Agnew.)

Dislocation of the Radius and Ulna.—This dislocation may take place backward, forward, outward, and inward.

Backward Dislocation of the Radius and Ulna at the Elbow.—This is one of the most common dislocations at the elbow-joint, and results from force directly or indirectly applied to the hand and forearm. The anterior and lateral ligaments are usually torn, the coronoid process of the ulna drops into the olecranon fossa of the humerus, and the radius occupies the posterior surface of the external condyle; the tendons of the biceps and the brachialis anticus muscles are stretched over the articular surface of the humerus. (Fig. 502.)

Symptoms.—The symptoms of this dislocation are anterior shortening of the forearm, with a marked prominence in front of the elbow, caused by the lower extremity of the humerus, and a prominence behind the elbow (Fig. 503), caused by the olecranon process of the ulna and the tendon of the triceps; the elbow is rigid, and flexion and extension are difficult.

Fig. 502.

Backward dislocation of the bones of the forearm. (Agnew.)

Fig. 503.

Deformity in backward dislocation of the bones of the forearm.

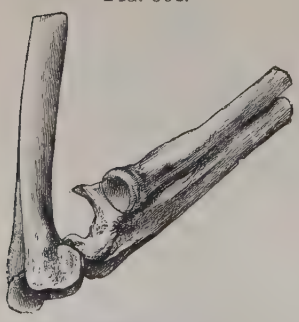
Diagnosis.—Posterior dislocations at the elbow are very frequently confounded with fractures of the condyles of the humerus or supracondyloid fracture of the humerus. In dislocation there is rigidity of the elbow, with a prominence in front of and another behind the elbow. The relative position of the olecranon process and the two condyles of the humerus is

disturbed in dislocation, but is not in fracture. In fracture the olecranon process and the external and internal condyles are on the same line; in dislocation the olecranon process occupies a position posterior to the condyles. The posterior projection in dislocation is increased by flexion and diminished by extension, whereas in fracture the posterior projection is diminished by flexion and increased by extension. In dislocation crepitus is absent; in fracture it can be obtained. In fracture the deformity disappears upon extension and counter-extension, but reappears as soon as the force is removed. In dislocation, when the deformity is once reduced by extension and counter-extension there is no tendency to its reproduction.

Treatment.—Reduction in recent cases is usually very easy, especially if muscular resistance is removed by the administration of an anæsthetic. It may be accomplished by fixing the arm and flexing the forearm and then making traction, or the same result may be obtained by fixing the arm and bringing the forearm into extension, when by making traction and sudden flexion the bones will slip into place. After reduction the arm should be placed upon a well-padded anterior angular splint, which is retained for two or three weeks, after the first week passive movements and massage being practised to prevent stiffness of the joint.

Forward Dislocation of the Radius and Ulna.—This is a rare form of dislocation, in which the radius and ulna occupy a position in front of the condyles of the humerus. (Fig. 504.) In complete dislocation of the radius and ulna forward the broad surface of the humerus can be felt posteriorly, with the olecranon process and the head of the radius anteriorly.

Fig. 504.



Anterior dislocation of the bones of the forearm. (Agnew.)

Treatment.—This dislocation may be reduced by making forced flexion of the forearm, and at the same time extension from the wrist.

Lateral Dislocations of Both Bones of the Forearm.—Lateral dislocations of the forearm are rare injuries: they are with few exceptions incomplete, and are produced by violence acting upon the lower and the upper arm in opposite directions. In incomplete outward dislocation the ulna is not entirely removed from the articular surface of the humerus; the radius may either remain in contact with the outer margin of the radial surface of the humerus or rest between the latter and the epicondyloid eminence. (Fig. 505.) When the dislocation is more complete the head of the radius may be entirely external to the external condyle, while the outer articular surface of the humerus occupies the sigmoid cavity of the ulna. In inward dislocation the ulna rests upon the internal condyle, and the head of the radius may be in the great sigmoid cavity or upon its anterior or posterior surface. (Fig. 506.) The ulna may also be displaced behind the internal condyle of the humerus, and the radius occupy the olecranon cavity, forming a postero-lateral dislocation.

Symptoms.—The arm is flexed and inclined inward or outward, the internal or external condyle is covered by the projection of the olecranon

process of the ulna or the radius, the external condyle is more prominent from the absence of the head of the radius, and the hand is pronated.

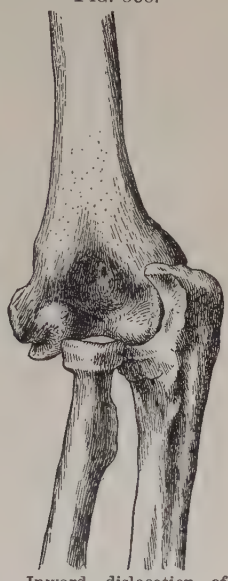
Treatment.—Reduction of these dislocations consists in grasping the forearm with one hand and the arm with the other and making extension and counter-extension while forcing the humerus and the bones of the forearm in opposite directions.

Postero-lateral dislocations should be treated as posterior dislocations, by bending the front of the elbow around the knee, or by flexion and extension conjoined with lateral pressure. The after-treatment of these dislocations is similar to that employed in posterior dislocations of the elbow.

Fig. 505.

Outward dislocation of the bones of the forearm. (After Agnew.)

Fig. 506.



Inward dislocation of the bones of the forearm. (After Agnew.)

Subluxation of the Head of the Radius.—This is a form of displacement which is observed in children and usually results from extension by pulling upon the forearm. It is not an uncommon accident. We have seen a number of cases, principally in dispensary practice. The arm rests against the side of the body, is partly flexed at the elbow, and is pronated. There is tenderness upon pressure over the head of the radius, and the patient refuses to use the arm. **Treatment.**—The surgeon seizes the arm with one hand and the forearm with the other, and upon making supination a sharp click is heard, and the motions of pronation and supination are restored. No special after-treatment is required.

Old Dislocations of the Elbow.—If the attempts at reduction are postponed for a week or longer it may be difficult or impossible to return the bones to their normal position. The patient should be anæsthetized, and, the adhesions being broken up so that the motions of flexion and extension can be freely made, attempts should be made to reduce the dislocation by manipulation. If these fail, the dislocation may be allowed to remain unreduced, or if the displacement of the bones is accompanied with pain, or the patient's arm is useless by reason of the limited motion, excision of the elbow may be resorted to, with a view to giving the patient increased motion, although a certain amount of weakness in the arm may result after the operation.

Compound Dislocations of the Elbow.—Compound dislocations of the elbow are serious injuries, but if the blood-vessels have not been torn the possibility of saving the limb is good. In the treatment of compound dislocations of the elbow the skin and the wound should be thoroughly ster-

ilized, and the surgeon may either reduce the displaced bone or, what seems to us the wiser procedure, make a partial excision of the joint, that is, if possible, remove the lower portion of the humerus and allow the articular surface of the ulna to come in contact with the sawn surface of the humerus. In compound dislocations of the elbow associated with fracture no definite rule can be given for excising portions of certain bones, the rule in such cases being to remove fragments involved in the fracture. After removing the necessary amount of bone, the wound should be drained and closed and a copious antiseptic dressing applied, and the arm secured upon an internal or an anterior angular splint. If the surgeon has succeeded in preventing infection of the wound, the repair in these cases is often very prompt, and the functional results following partial excision when associated with fracture we think are superior to those following the simple reduction of the displaced bone.

Dislocation of the Inferior Radio-Ulnar Articulation.—This dislocation consists in a separation of the lower extremity of the ulna from the semilunar cavity of the radius, and the ulna may be displaced either backward or forward. The injury is often associated with fracture of the lower end of the radius.

Backward Dislocation.—This usually results from extreme and violent pronation of the hand, and may be associated with a fracture of the carpal extremity of the radius. The posterior radio-ulnar and sacciform ligaments are often ruptured, and the triangular interarticular cartilage is disconnected at its apex from the root of the styloid process of the ulna. **Symptoms.**—The symptoms of this injury are a movable prominence at the back of the wrist at the inner side, the styloid process of the ulna being no longer in line with the fifth metacarpal bone. The hand is in a state of supination, and the fingers are flexed. **Treatment.**—To reduce this displacement the hand should be extended, to relax the extensor carpi ulnaris muscle, and the displaced bone at the same time should be pressed directly backward into the semilunar cavity. There is often a strong tendency to the reproduction of the displacement, which can be counteracted by the use of a firm compress placed over the posterior surface of the bone, and the application of a straight padded or Bond's splint; this should not be removed permanently for three or four weeks. After the removal of the splint it is wise to give some fixation to the part by strapping the wrist with rubber plaster or by the use of a compress and bandage for a considerable time.

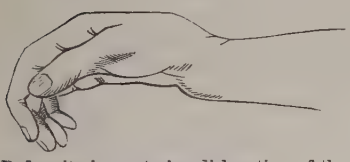
Forward Dislocation.—This displacement is caused by violent supination of the hand, and is usually accompanied by rupture of the anterior ligaments of the joint. **Symptoms.**—A prominence may be felt under the palmar surface of the wrist, somewhat to the radial side, and it will be noticed that the prominence of the lower end of the ulna at the back of the wrist is absent; the hand is supinated. **Treatment.**—The forearm should be flexed, and extension made from the hand and counter-extension from the arm. By forced pronation, and by pressing the head of the ulna backward, it may be made to take its natural position in the semilunar cavity of the radius. Having reduced the deformity, the forearm should be fixed by two well-padded straight splints, the dressing being similar to that em-

ployed in fractures of both bones of the forearm. These splints should be retained for about four weeks.

Dislocations of the Wrist.—These are comparatively rare dislocations, and may be either backward or forward.

Posterior Dislocation at the Wrist.—This displacement follows the application of force to the back of the hand, producing extreme flexion, which causes rupture of the posterior radio-carpal and lateral ligaments, and allows the carpus to rest upon the posterior surface of the radius and ulna. The most marked symptom is deformity, which consists in thickening in the antero-posterior diameter of the wrist, and fixation of the wrist with the hand slightly extended and the fingers flexed. (Fig. 507.) **Treatment.**—This displacement may be reduced by grasping the hand of the patient and making extension with slight flexion, abduction, and adduction.

FIG. 507.



Deformity in posterior dislocation of the wrist. (Agnew.)

FIG. 508.

Deformity in anterior dislocation of the wrist. (After Agnew.)

When the deformity has been reduced it has no tendency to reappear, and it should be afterwards treated by the application of a straight splint, worn for several weeks.

Anterior Dislocation at the Wrist.—This displacement may result from forcible extension of the wrist: the anterior carpal and lateral ligaments are ruptured, and the bones of the carpus rest upon the anterior surface of the radius. **Symptoms.**—The symptoms of this displacement are fixation of the hand in the extended position and a prominence upon the posterior surface of the wrist of the lower end of the radius and ulna (Fig. 508). **Treatment.**—Reduction is accomplished by making extension from the hand with counter-extension from the arm, at the same time the carpus being extended upon the forearm and the ends of the ulna and radius pressed forward. Afterwards the hand and forearm should be placed upon a well-padded straight splint, or upon a Bond's splint, and secured by the application of a roller bandage.

Dislocation at the wrist is most apt to be confounded with fracture of the lower end of the radius, but may easily be distinguished from this injury if the surgeon observes the following points: fracture at the lower end of the radius presents somewhat the same deformity; but there is not marked fixation at the wrist, and upon reduction of the deformity by extension and manipulation as soon as the extending force is removed the deformity usually reappears. In dislocation there is rigidity of the wrist, and, after the reduction has been accomplished, upon the withdrawal of the extending force there is no tendency to the reproduction of the displacement.

Compound Dislocations of the Wrist.—Compound dislocations of the wrist are serious injuries, and are often associated with extensive laceration of the skin, ligaments, and tendons in connection with the wrist-joint. If the principal blood-vessels and nerves remain uninjured, although there may be extensive laceration of the soft parts, with comminution of the bones, it is often possible to save the part and to secure a useful hand. In cases where there is extensive comminution of the bones, the loose fragments should be removed and the wound and the surrounding skin should be sterilized. After reducing the displacement the part should be placed upon a well-padded palmar splint and a copious antiseptic dressing applied. In cases of ruptured nerves or tendons associated with this injury, these should be brought together with sutures, and important vessels, if injured, secured by ligatures.

Congenital dislocations of the carpus are occasionally seen, in which the carpus may be displaced backward, forward, or laterally. The *treatment* of these cases has not, as a rule, been satisfactory, but in every case an attempt should be made to secure fixation of the wrist in its normal position by splints or mechanical appliances which allow of motion in certain directions and yet prevent the displacement of the bones.

Dislocation of the Carpal Bones.—Displacements of single bones of the carpus are rare, from the fact that the bones are bound together by strong ligaments. Those most liable to be displaced are the os magnum, the semilunar, and the pisiform.

Dislocation of the Os Magnum.—This is recognized by a prominence immediately behind the carpal extremity of the third metacarpal bone. This displacement is reduced by pressing the bone back into place, after which a compress should be applied over it, and the hand and forearm fixed upon a well-padded splint.

Dislocation of the Semilunar Bone.—This injury is characterized by the presence of a hard body on a line with the metacarpal bone of the index finger and below the posterior margin of the carpal extremity of the radius. It is reduced by making extension from the hand and pressing the bone forward and upward; the hand and forearm should then be placed upon a palmar splint.

Dislocation of the Pisiform Bone.—When this occurs the bone is detached from the cuneiform bone and drawn upward, and often can be recognized as a hard mass above the wrist. In reducing this displacement the hand should be flexed and the displaced bone drawn downward, and the hand fixed upon a splint in the flexed position.

Dislocation of the Metacarpus.—Dislocation of the metacarpus as a whole is extremely rare. The accident will be recognized by a prominence on the back and front of the hand, with shortening of the hand. (Fig. 509.) **Treatment.**—Reduction is accomplished by extension and counter-extension, with manipulation, and after the deformity has been reduced the hand and forearm should be placed upon a palmar splint and a compress applied over the carpo-metacarpal joints.

Dislocations of the Metacarpal Bones.—These are generally compound. The soft parts are apt to be extensively lacerated, and excision of

one or more bones or amputation may be demanded. If, however, the soft parts have not been extensively injured, the displaced bones should be reduced by extension and direct pressure, and, after sterilizing and dressing the wound with a gauze dressing, the hand and forearm should be immobilized by the application of a palmar splint.

Fig. 509.

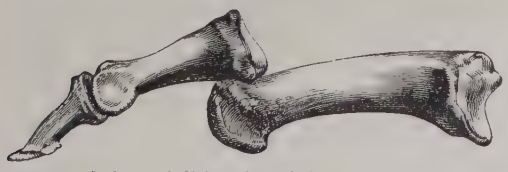
Forward dislocation of the metacarpus. (Agnew.)

Dislocation of the Metacarpal Bone of the Thumb.—This may take place either backward or forward, and usually results from extreme flexion or extreme extension of the thumb. The symptoms are shortening of the thumb and a prominence below the styloid process of the radius. **Treatment.**—Reduction is effected by grasping the proximal phalanx of the thumb and pressing the carpal extremity of the metacarpal bone downward. The tendency to reproduction of the deformity is usually marked, and to prevent this a moulded binders' board splint should be fitted to the thumb and wrist and secured by a narrow roller bandage.

Dislocations of the Thumb.—The most common dislocation of the thumb is a displacement, either forward or backward, of its proximal phalanx.

Backward Dislocation.—This dislocation usually results from force applied to the phalanx while it is in a state of flexion, causing a displacement of the proximal end of the phalanx behind the head of the metacarpal bone. (Fig. 510.) This displacement is one which presents marked deformity (Fig. 511), and its reduction is often attended with great difficulty. The difficulty in reduction seems to arise from the fact that the neck of the metacarpal bone is grasped between the heads of the short flexor of the thumb. **Treatment.**—This displacement may be reduced by fixing the metacarpal bone of the thumb and extending the thumb, and then drawing it downward and suddenly flexing it, by which manipulation the displaced bone may slip into place. In other cases, in spite of all manipulations, it may be found impossible to reduce the deformity; one head of the short flexor should then be divided subcutaneously, and by making the foregoing manipulations the displacement may be reduced. Or

Fig. 510.



Metacarpo-phalangeal dislocation of the thumb. (Agnew.)

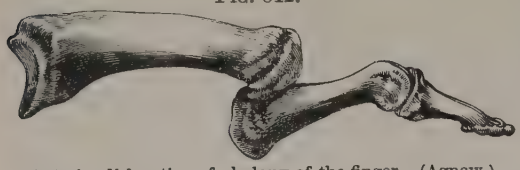
Fig. 511.

Deformity in backward dislocation of the proximal phalanx of the thumb.

the displaced bone may be exposed by an incision, and any structures which interfere with its reduction divided and the displacement reduced.

Dislocations of the Phalanges of the Fingers.—These may be metacarpo-phalangeal or interphalangeal (Fig. 512), and are usually not difficult of reduction; in such cases reduction can be accomplished by over-extension of the distal phalanx, followed by manipulation and flexion. (Fig. 513.) The after-treatment consists in fixing the displaced bone by the application of a moulded binders' board splint for a few weeks and in practising passive motion to restore the function of the joint.

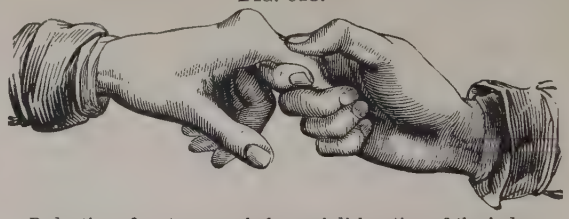
Fig. 512.



Anterior dislocation of phalanx of the finger. (Agnew.)

Compound Dislocations of the Phalanges.—In compound dislocations of the phalanges the wound should be thoroughly sterilized and the dislocation should be reduced, the wound closed, and the parts fixed by a moulded binders' board splint. Where there is extensive comminution of the bones in conjunction with dislocation of the phalanges, excision of the comminuted portions should be practised.

Fig. 513.



Reduction of metacarpo-phalangeal dislocation of the index finger. (Agnew.)

DISLOCATION OR DIASTASIS OF THE BONES OF THE PELVIS.

Diastasis of the bones of the pelvis results from heavy bodies passing over the pelvis, or from crushing forces such as occur in railway accidents, and is often associated with fracture of the pelvic bones. The diastasis in the pelvic bones is most commonly seen at the sacro-iliac symphysis or the pubic symphysis. **Symptoms.**—A patient who has sustained a pubic or a sacro-iliac diastasis is unable to stand, and complains of a sense of falling apart in the region of the pelvis, and upon examination, by grasping the bony prominences of the pelvis and making motion, mobility can usually be felt at the region of separation. **Treatment.**—The treatment of pelvic diastasis consists in placing the patient in bed upon his back on a firm mattress, and, after reducing the displacement by manipulation, applying a stout muslin binder around the pelvis, or the latter may be strapped with broad strips of adhesive plaster. This support should be retained for a period of a month or six weeks; at the end of this time union is sufficiently firm to allow the patient to get up and walk about.

Dislocation of the Coccyx.—This injury may result from force received directly upon the region of the coccyx, and consists in a forward displacement of this bone. The amount of pain and disability following the anterior displacement of the coccyx is out of proportion to the extent of the injury. This injury may be diagnosed by introducing the finger into

the rectum and feeling the coccyx displaced forward. Its reduction is accomplished without difficulty by manipulation with the fingers in the rectum. After reduction the displacement is apt to recur, and if it is accompanied with much disability and pain, the most satisfactcry treatment consists in cutting down upon the coccyx and excising the displaced portion.

DISLOCATIONS OF THE HIP.

Dislocations of the hip have been observed at all ages, but are most frequent in adult life, and are more common in males than in females. The head of the femur may be primarily displaced—*upward*, *backward*, *downward*, and *forward*—and may also undergo a number of secondary displacements. The mechanism of dislocations of the hip has been very carefully described by Bigelow, who considers that the typical displacements of the hip result when the ilio-femoral or Y ligament remains untorn in whole or in part. The Y ligament consists of a mass of fibrous tissue composed of two branches, which have a common origin from the anterior inferior spinous process of the ilium, the external portion being inserted into the outer part of the anterior intertrochanteric line, and the inner part into the internal portion of the same ridge. This ligament serves to reinforce anteriorly the capsule of the hip-joint. (Fig. 514.) Bigelow held the opinion that typical dislocations of the hip resulted when both branches of the Y ligament remained untorn, and that in irregular dislocations both branches of the Y ligament were ruptured, the head of the bone then occupying almost any position intermediate to the regular ones. Allis holds that the head of the bone in all dislocations of the hip escapes from the lower segment, and when outward is first dorsal, and then may be displaced upward or downward; when inward is first thyroid, and then may be displaced upward or downward.

Fig. 514.

Ilio-femoral or Y ligament.

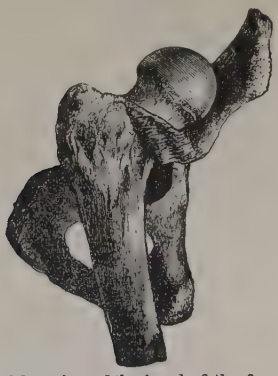
Dislocation of the Hip Upward and Backward (Iliac).—In this dislocation the head of the femur after escaping from the acetabulum rests upon the dorsum of the ilium. (Fig. 515.) This dislocation may result from falls upon the knee or the foot when the limb is adducted, or from force applied to the back when the pelvis is flexed upon the thighs, or from the foot and thigh being fixed while the pelvis is forcibly twisted.

Symptoms.—The symptoms of iliac dislocation of the hip are flexion and adduction of the thigh, marked prominence of the great trochanter, inversion of the foot, and fixation or rigidity of the hip-joint. (Fig. 516.) There is also marked shortening of the limb, varying from one to three inches, and the head of the bone in certain cases may be felt in its abnormal position.

Diagnosis.—Iliac dislocation of the hip is often confounded with fracture of the neck of the thigh-bone, but little difficulty should be experienced if the surgeon bears in mind the facts that in dislocation of the hip the

trochanter is very prominent, the knee is adducted, the limb flexed, and the foot inverted, that there is no crepitus, and there is immobility at the hip-joint; the limb cannot be restored to its proper length by the application of ordinary force, and when the deformity is once reduced it does not tend to recur. In fracture of the neck of the femur the trochanter is not prominent, the foot is everted, the knee is not adducted, and the limb is not flexed; crepitus can often be obtained, and there is preternatural mobility at the hip-joint. Extension restores the limb to its proper length, but upon the removal of the extending force the shortening reappears.

Fig. 515.



Dislocation of the head of the femur upon the dorsum of the ilium.

Fig. 516.

Deformity in dorsal dislocation.

Dislocation of the Hip Backward (Ischiatic).—In this dislocation, which Bigelow describes as dorsal below the tendon of the obturator internus muscle, the head of the bone is dislocated into the sacro-sciatic notch. (Fig. 517.) This dislocation results from force applied to the knee, foot, or pelvis when the thigh is flexed upon the pelvis.

Fig. 517.

Ischiatic dislocation of the head of the femur.

Symptoms.—In this dislocation the limb is slightly flexed, inverted, and adducted, and the knee is turned towards its fellow and touches the thigh at the inner margin of the patella. (Fig. 518.) The shortening is rarely more than half an inch; the hip is less prominent, and the trochanter is farther from the anterior superior spinous process of the ilium, than in the dorsal dislocation. The bone is less movable and its head is lower than in the iliac variety.

Treatment.—Reduction of iliac and ischiatic dislocations may be accomplished by manipulation or by extension and counter-extension. In

the former method the patient is placed upon his back upon a firm mattress and anæsthetized; the surgeon then grasps the ankle of the injured limb with one hand and the front of the knee with the other; the leg is flexed on the thigh, and the thigh on the pelvis. Flexing the thigh in iliac dislocations relaxes the ilio-femoral ligament, and in ischiatic dislocations disengages the head of the femur from the obturator internus muscle. It is then adducted and carried to the sound side, rotated slightly outward, and finally, by external circumduction, is swept across the abdomen and brought down in a straight position beside its fellow. (Fig. 519.) Adduction brings the head of the bone close to the articular cavity, while external rotation and circumduction shorten the outer branch of the ilio-femoral ligament and raise the head of the bone over the acetabulum. Under this manipulation the head of the bone usually slips into the acetabulum.

Fig. 518.

Deformity in ischiatic dislocation of the femur.

Fig. 519.

Reduction of backward dislocation of the femur. (Bryant.)

Allis in the reduction of dorsal dislocations recommends that while the patient is supine the surgeon kneel beside him, and, in the case of the right hip, grasp the ankle with the right hand and place the bent elbow of the left arm beneath the knee. He then turns the bent leg outward by means of the ankle and lifts upward, and next turns the leg inward and brings the femur down in extension.

Reduction by Extension and Counter-Extension.—Reduction by extension and counter-extension by the use of the pulley and extending bands was formerly frequently practised for the reduction of dislocations of the head of the femur. This method is not often practised at the present time, as by its use much greater violence is done to the parts, and on the whole it is not so satisfactory as the treatment by manipulation. It may, however, be required in some cases of old dislocation of the femur.

Dislocation of the Hip Downward and Forward (Thyroid).—In this dislocation the head of the bone, after escaping from the acetabulum, lodges over the thyroid foramen upon the obturator externus muscle. (Fig. 520.) It is produced by force acting upon the limb while it is in a state of abduction.

Symptoms.—The limb is lengthened about an inch and a half, the heel is raised, and the foot may be slightly everted; the hip is flattened, and the body inclined forward on the pelvis and towards the injured side. (Fig. 521.) The head of the bone may be felt below the horizontal ramus of the pubis.

Treatment.—The leg should be flexed upon the thigh, and the thigh carried up to a right angle with the pelvis. The limb is next abducted and rotated inward and carried across the abdomen towards the sound side and brought down in the position of adduction to the side of its fellow. (Fig. 522.) During attempts at the reduction of thyroid dislocations it is quite common for the head of the bone to pass below the acetabulum and convert the thyroid into an ischiatic or an iliac dislocation, in which event the reduction may be accomplished by adopting the manipulations for the reduction of iliac or ischiatic displacements. To prevent

FIG. 520.

Thyroid dislocation of the femur.

FIG. 521.

Deformity in thyroid dislocation of the femur.

this complication during the reduction of thyroid dislocations a folded towel may be placed beneath the upper part of the thigh, and by raising the latter at the moment the limb begins to descend, the head of the bone may be prevented from slipping below the acetabulum.

FIG. 522.

Reduction of thyroid dislocation of the femur.

FIG. 523.

Pubic dislocation of the femur.

Dislocation of the Hip Upward and Forward (Pubic).—In this form of dislocation, which is the least frequently seen, the head of the bone after escaping from the acetabulum rests upon the pubis internal to the

pubic eminence. (Fig. 523.) It is produced by falls upon the foot or upon the knee, when the thigh is thrown behind the perpendicular, or may be produced by violent twists of the limb.

Symptoms.—The limb is shortened and abducted, the thigh is flexed, the foot is everted, the head of the bone can be felt in front of the pubis, and the trochanter is not prominent. (Fig. 524.) This form of dislocation is also apt to be confounded with fracture of the neck of the femur. In fracture of the neck of the femur there are crepitus and mobility; the thigh is not flexed nor abducted. In pubic dislocation there are absence of crepitus, immobility, abduction and flexion of the thigh, and the head of the bone can be felt in front of the pubis.

Fig. 524.

Deformity in pubic dislocation of the femur.

Treatment.—The leg should be flexed on the thigh, and the thigh on the pelvis, to its fullest extent, so that it shall be brought in contact with the abdomen, which manipulation relaxes the ilio-femoral ligament and dislodges the head of the bone from the pubis. Then after making internal rotation and adduction the limb should be brought down, inclined towards the sound side. Allis, in the reduction of anterior or inward dislocations, recommends flexing the thigh, then adducting it, carrying the knee obliquely inward and downward, and then rotating outward.

Anomalous Dislocations of the Hip.—As before stated, anomalous or atypical dislocations are likely to result where both branches of the ilio-femoral or Y ligament have been ruptured. In these the head of the bone assumes a number of different positions. Anomalous dislocations of the hip are classified as those which occupy a position above the level of the acetabulum, *upward*, and those below the level of the acetabulum, either downward or forward, *subpubic*.

Dislocations of the Hip directly Upward (Supracotyloid).—In this dislocation the head of the bone is displaced upward, and rests a little to the side of the anterior superior spine of the ilium. *Reduction* is effected by flexion and abduction of the limb.

Dislocation Downward upon the Tuberosity of the Ischium.—This dislocation is rare. The limb is flexed, and may be somewhat abducted and everted. *Reduction* is usually accomplished without much difficulty by traction and flexion.

After-Treatment of Dislocation of the Hip.—After reduction of dislocations of the femur it is usually well to apply a sand-bag to the outer side of the limb, or to secure the limbs together by a bandage, and the patient should be kept in bed and not allowed to use the limb for two or three weeks, until a sufficient time has elapsed to have the rent in the capsular ligament firmly healed.

Complications in Dislocations of the Hip.—Dislocations of the hip may be complicated by fracture of the lip of the acetabulum, which renders the reproduction of the dislocation likely after reduction. Fracture of the

neck of the femur may also occur in attempts to reduce these dislocations. In the event of such an accident efforts should be made to replace the head of the bone in the acetabulum by manipulation, but this is not likely to be successful, and the case should be treated as one of fracture of the neck of the femur, when a fairly useful limb may result, or excision of the head of the bone may be practised.

Compound dislocations of the femur are rare accidents, and are usually produced by great violence. In such a case an attempt should be made to reduce the displaced bone, and if this cannot be successfully done, the head of the bone should be excised. Injury of the femoral vessels is not common in dislocation of the femur, but has occasionally occurred in pubic dislocations.

Old Dislocations of the Femur.—The reduction of old dislocations of the femur is usually a matter of the greatest difficulty. After the head of the bone has been dislocated for a few weeks it is often impossible to replace it. An old ischiatic or obturator dislocation is less amenable to treatment than a pubic or an iliac dislocation. In old dislocations of the femur the head of the bone may undergo changes, or the acetabulum may become more shallow from filling up or from the absorption of the edges, so that it will be difficult for the bone to remain in place in case of its reduction. Attempts to reduce dislocations of the femur are usually not successful after several months, but cases of months' or even years' standing have been reduced. The reduction of old dislocations of the femur should be attempted if the displacement causes great disability or pain.

Treatment.—The patient should be anæsthetized, and motion made to break up adhesions as far as possible; then the proper manipulations for the reduction of particular dislocations should be practised. If these fail, extension and counter-extension may be employed by the use of the pulley and extending bands, or the method of angular extension suggested by Bigelow may be employed: we succeeded in reducing a dorsal dislocation of the femur of six weeks' standing by the use of this method. Where reduction cannot be accomplished, excision of the head of the bone has been practised with good results, and this operation should be considered in suitable cases. Should fracture occur near the head of the bone during attempts at reduction of an old dislocation, further manipulations should be abandoned, and the limb dressed in such a position as to diminish the deformity, with the chance that a false joint might occur at the seat of fracture, giving the patient a more useful limb.

DISLOCATIONS OF THE PATELLA.

These occur from blows or falls upon the side of the bone, especially when the knee is slightly flexed, or may result from muscular violence. The patella may be dislocated outward, inward, vertically, upward, or downward.

Outward Dislocation.—The outward or external dislocation of the patella is the most common, because the bone lies in the tendon of the quadriceps extensor cruris muscle, and the tendo patellæ is attached at an angle the vertex of which is directed towards the internal condyle. Forcible con-

traction of the quadriceps muscle has a tendency to convert the angle into a straight line, and the patella is thrown outward. The bone may also be displaced by direct violence. **Symptoms.**—The breadth of the knee is increased, the internal condyle becomes unusually prominent, the limb is a little flexed, and the joint is fixed. (Fig. 525.) The borders of the patella may be felt, one anteriorly, the other posteriorly. **Treatment.**—Reduction is effected by placing the patient on his back and relaxing the quadriceps extensor cruris muscle by elevating the leg, when the patella can usually be pressed back into place with the fingers. The after-treatment consists in the application of a posterior padded splint or a plaster of Paris bandage to fix the knee-joint, which should be worn for two or three weeks.

Fig. 525.

Outward dislocation of the patella. (Agnew.)

Fig. 526.

Inward dislocation of the patella. (Agnew.)

Inward Dislocation of the Patella.—This luxation is an extremely rare one. **Symptoms.**—The knee is slightly flexed, and the patella is found resting against the articular surface of the internal condyle. (Fig. 526.) **Treatment.**—This dislocation is reduced by the same manipulation as that for the reduction of external dislocation of the patella, except that the patella is pressed outward: the after-treatment of the case is similar.

Fig 527.

Vertical dislocation of the patella. (Agnew.)

Vertical Dislocation of the Patella.—Here the patella rests upon its edge in the groove between the condyles, or there may be a semi-revolution of the bone on its axis. (Fig. 527.) **Symptoms.**—The leg is extended, and the edge of the patella can be recognized under the skin in front of the knee. The extensor muscles are in a state of tension. **Treatment.**—Reduction is accomplished, after anæsthetizing the patient, by flexing the thigh upon the abdomen, and while the limb is held in this position an assistant alternately flexes and extends the leg, while the surgeon manipulates the bone with his fingers until it slips into place. The after-treatment consists in fixation of the knee-joint for a few weeks by the application of a posterior splint, or by the use of a plaster of Paris bandage.

Upward and Downward Dislocations of the Patella.—These dislocations can result only from elongation or rupture of the ligamentum patellæ or the tendon of the quadriceps extensor. **Symptoms.**—The symptoms of either of these dislocations are similar to those of fracture of the patella. **Treat-**

ment.—This consists in the use of a posterior splint and adhesive straps to draw the fragments into position, the dressing being very similar to that employed in fractures of the patella; or a more satisfactory treatment is to cut down upon the ruptured tendon and suture the divided ends together with silk or kangaroo tendon sutures; or, if it has been torn loose from the bone, to drill the bone and pass kangaroo tendon sutures through the drill-holes, and secure them to the ruptured end of the tendon.

Congenital displacements of the patella have been observed in a few cases. The treatment consists in the application of a brace.

In cases of displacement of the patella from pathological causes, such as relaxation of the ligaments, the *treatment* consists in the use of a compress and a bandage, or the application of a brace, which limits the motion of the knee and at the same time prevents displacement of the patella.

DISLOCATIONS OF THE KNEE.

Dislocations of the knee are infrequent injuries, and result only from the application of great force. The ligaments are very strong, and occupy the internal, external, and posterior aspects of the joint, while in front the patella with its tendon gives additional strength to the articulation. Dislocations of the knee-joint may be backward, forward, lateral, or rotatory.

Forward Dislocation of the Knee.—This may be complete or incomplete, and may result from over-extension of the knee, or from direct violence received upon the front of the thigh or the back of the leg. **Symptoms.**—In this dislocation, if complete, the leg is shortened from one to three inches, and may be extended or slightly flexed. Two prominences are observed, one in front of the knee, caused by the head of the tibia, and the other behind the knee, produced by the lower extremity of the femur. (Fig. 528.) The patella may rest in front of the tibia or in the depression above the latter. **Treatment.**—The patient, having been anæsthetized, is placed upon his back; extension is made upon the leg and counter-extension upon the thigh, and, the surgeon's arm being placed beneath the joint, the leg is gradually flexed. Under this manipulation the bones usually slip into place. The after-treatment consists in fixation of the joint by the application of a posterior padded splint; the region of the joint should also be covered for a few days with lint saturated with lead water and laudanum. As soon as the swelling has subsided the knee-joint should be fixed in the extended position by the application of a plaster of Paris bandage, which should be retained for about three weeks, after which the patient should be allowed to use the limb, but the joint motions should be restricted for some weeks by some form of splint or brace.

Fig. 528.

Forward dislocation of the knee. (Agnew.)

Backward Dislocation of the Knee.—This dislocation may be complete or incomplete, and is generally due to violence received upon the front of the leg or the back of the thigh. The patella is usually dislocated outward at the same time, and the leg is in a position of hyper-extension. (Fig. 529.) In this displacement the posterior ligament is ruptured, and the heads of the gastrocnemius,

Fig. 529.

Posterior dislocation of the knee. (After Agnew.)

Fig. 530.

Incomplete internal dislocation of the knee. (Agnew.)

Fig. 531.

Incomplete external dislocation of the knee. (Agnew.)

popliteus, and quadriceps muscles, together with the popliteal vessels, are placed upon the stretch. **Symptoms.**—The leg is shortened and bent forward or extended; a depression exists in front of the joint, the condyles of the femur can be felt anteriorly, and the head of the tibia projects posteriorly. **Treatment.**—The reduction and after-treatment of this dislocation is similar to that employed in anterior dislocation.

Lateral Dislocations of the Knee.—These may be either external or internal, and are generally incomplete. In internal lateral dislocation the head of the tibia is carried inward, so that the internal condyle of the femur rests upon the outside of the internal articular surface of the head of the tibia. (Fig. 530.) In external lateral dislocation the tibia is carried externally, and the external condyle of the femur rests upon the inner portion of the outer articular surface of the head of the tibia. (Fig. 531.) In either of these dislocations the patella is displaced, and there is a laceration of the lateral ligaments as well as of the crucial ligaments. **Symptoms.**—When the displacement is internal, the knee-joint presents a marked increase in its transverse diameter, and the internal tuberosity of the tibia can be felt upon the inner aspect of the joint; upon the outer side a prominence can be detected, which is the external condyle of the femur. In external dislocations two prominences can also be felt, composed of the internal condyle of the femur and the outer side of the external tuberosity of the tibia. **Treatment.**—Reduction is usually accomplished without difficulty, by making extension and counter-extension and pressing the displaced bones back into their nor-

mal position. The after-treatment of lateral dislocations is similar to that of other dislocations of the knee.

Rotatory Dislocation of the Knee.—This is a rare displacement, in which the head of the tibia is twisted either inward or outward. In the external variety the bones of the leg are twisted, so that the internal angle of the tibia is directed forward and externally, the fibula is directed backward, a marked prominence of the patella is seen externally, and the internal condyle of the femur is also prominent, while the inner border of the calf of the leg presents anteriorly. (Fig. 532.) **Treatment.**—Reduction is accomplished by making extension and counter-extension and at the same time twisting the leg either externally or internally, according to the direction of the displacement.

Fig. 532.

Rotatory dislocation of the knee. (Agnew.)

Compound Dislocations of the Knee.—Compound dislocations of the knee-joint result from the application of great force, and are often accompanied by laceration of important vessels and nerves in the popliteal space. In cases of compound dislocation of the knee-joint accompanied by extensive destruction of the soft tissues and laceration of the popliteal blood-vessels, primary amputation is usually required. If, however, the injury to the soft parts is not extensive and the vessels have escaped injury, the wound should be thoroughly sterilized, drainage should be introduced, and after reduction of displaced bones the wound should be closed, a copious antiseptic dressing applied, and the knee dressed in the extended position and fixed in this position by the application of splints or a plaster of Paris bandage.

Compound dislocations of the knee, complicated with comminution of the head of the tibia or the condyles of the femur, the vessels being uninjured, are cases in which primary excision of the joint may be employed with advantage. In such cases, after partial or complete excision of the joint, drainage should be introduced, the wound closed, a copious antiseptic dressing applied, and motion at the knee controlled by the application of a posterior splint or a plaster of Paris bandage.

Congenital Dislocations of the Knee.—Congenital dislocations of the knee have occasionally been observed, affecting one or both knees. The reduction of the dislocation in these cases is soon followed by its reappearance. The most satisfactory method of treatment consists in the application of a brace which limits the motion of the joint and is provided with pads which prevent the bones from slipping out of place.

DISLOCATIONS OF THE FIBULA.

The fibula may be displaced from the tibia at its upper or at its lower extremity.

Dislocation of the Head of the Fibula.—The upper end of the fibula may be dislocated forward or backward. The anterior and posterior

tibio-fibular ligaments are torn, and the head of the bone may slip either forward or backward. The symptoms are inability to bear any weight upon the limb, and mobility of the head of the fibula. **Treatment.**—Reduction is accomplished by flexing the leg upon the thigh, to relax the biceps muscles, when the head of the bone can usually be pressed into its normal position. The limb should then be fixed upon a moulded binders' board splint, with a compress over the head of the fibula, or a plaster of Paris dressing may be applied.

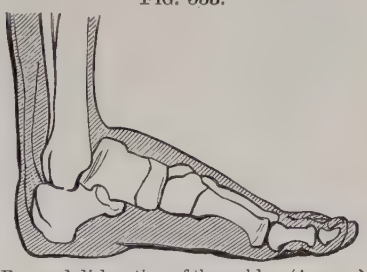
Dislocation of the Lower Extremity of the Fibula.—A few cases of this dislocation have been recorded, in which the lower end of the fibula has been torn from its attachments to the tibia and the foot and has been displaced backward. **Treatment.**—Reduction is accomplished by making extension and manipulation at the same time, and after the bone has been returned to its proper place the foot and leg should be fixed with a moulded binders' board splint, or by the application of a plaster of Paris bandage.

DISLOCATIONS OF THE FOOT OR THE ANKLE.

Dislocation of the ankle unaccompanied by fracture of the malleoli is an uncommon accident. Dislocation of the foot may be either forward, backward, or lateral.

Forward Dislocation of the Ankle.—This may result from force applied to the front of the leg when the foot is flexed or from falls on the heel when the tarsus is flexed, and is apt to be accompanied by a fracture of one or both malleoli. The lateral and anterior ligaments are ruptured, the astragalus escapes from the cavity between the tibia and the fibula, and the articular surface of the tibia rests upon the upper surface of the calcaneum. (Fig. 533.) The symptoms of this dislocation are lengthening of the foot and shortening of the heel, the malleoli may be felt lower down than usual, and the tendo Achillis is not prominent and rests against the tibia. **Treatment.**—Reduction is accomplished by flexing the leg upon the thigh, in order to relax the gastrocnemius and soleus muscles, and making extension from the foot, with counter-extension from the knee; the bones of the leg should be drawn forward by an assistant at the same time that the foot is forced backward. It is usually necessary to administer an anæsthetic, and in difficult cases the reduction may be facilitated by subcutaneous division of the tendo Achillis. After reduction the leg and foot should be fixed by the application of moulded binders' board splints, or by the use of a fracture-box, and as soon as the swelling has diminished, a plaster of Paris bandage should be applied.

Fig. 533.



Forward dislocation of the ankle. (Agnew.)

Backward Dislocation of the Ankle.—This displacement is caused by the foot being driven backward while in the extended position. The lateral and anterior ligaments are ruptured, and the bones of the leg occupy a position in front of the astragalus. (Fig. 534.) The tibia may rest in contact with the scaphoid bone, or upon the neck or the head of the astragalus.

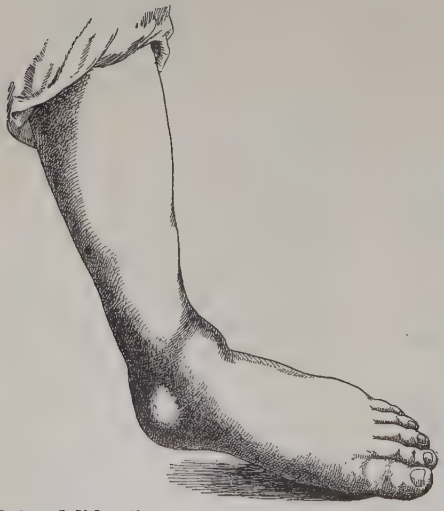
In this dislocation, as well as in the forward variety, fracture of the external or internal malleolus may be associated with the injury. **Symptoms.**—The symptoms are shortening of the foot and lengthening and elevation of the heel; the tendo Achillis stands out prominently upon the posterior portion of the leg. **Treatment.**—Reduction is accomplished by flexing the leg upon the thigh and making extension and counter-extension from the foot and leg; at the same time the surgeon forces the bones of the leg backward and draws the foot forward. In cases in which much difficulty is experienced, subcutaneous division of the tendo Achillis greatly facilitates the reduction and overcomes the subsequent tendency to displacement. The after-treatment is similar to that employed in forward displacement.

FIG. 534.

Backward dislocation of the ankle. (Agnew.)

Outward Dislocation of the Ankle.—This dislocation is produced by force which drives the foot into a state of extreme abduction, and is usually associated with rupture of the internal lateral ligament and fracture of the external malleolus. (Fig. 535.) The symptoms are marked eversion of the foot, prominence of the internal malleolus, and a depression over the lower portion of the fibula, which marks the site of the fracture of

FIG. 535.



Outward dislocation of the ankle with fracture of the fibula. (Agnew.)

FIG. 536.

Inward dislocation of the ankle. (Agnew.)

that bone. **Treatment.**—Reduction is accomplished by making extension and counter-extension and at the same time bringing the foot into a position of adduction. After reduction lateral moulded binders' board splints should be fitted to the leg, with one compress applied between the external splint

and the outer portion of the foot, and a second between the internal splint and the leg just above the internal malleolus, the splints being held in position by the turns of a roller bandage. A fracture-box with compresses may also be employed. In a few days, after the swelling has subsided, the foot and leg should be dressed with a plaster of Paris dressing, the foot being held in an inverted position until the plaster has become firm.

Inward Dislocation of the Foot.—This dislocation is much less common than outward dislocation, and may result from falls sustained upon the outer border of the foot, causing forcible adduction or inversion of the foot. **Symptoms.**—The foot is very much inverted, and the external malleolus is prominent and may be felt beneath the skin. (Fig. 536.) **Treatment.**—Reduction is accomplished by making extension upon the foot and counter-extension upon the leg, and by manipulation, bringing the foot into its normal position. The after-treatment consists in fixing the foot in a slightly everted position by the use of binders' board splints or the plaster of Paris bandage.

Compound Dislocation of the Ankle.—Compound dislocations of the ankle are the most frequent compound dislocations met with, and the results following this injury were formerly so unsatisfactory, as regarded the loss of life from septic infection and the loss of function in the limb, that the majority of cases were subjected to primary amputation. At present more conservative methods of treatment are adopted, with most gratifying results. In compound dislocations of the ankle-joint the foot is usually everted, and the articular surface of the tibia is driven through a wound in the soft parts (Fig. 537), or occasionally the compound dislocation may consist in an inward displacement of the foot, with protrusion of the astragalus through a wound at the outer aspect of the ankle, and fracture of the external malleolus. Compound dislocations of the ankle-joint, particularly those in which the tibia or the astragalus escapes from a wound at the inner aspect of the joint, are often associated with a rupture of the posterior tibial artery or nerve.

FIG. 537.

Compound dislocation of the ankle-joint. (Agnew.)

Treatment.—In the treatment of this injury the greatest care should be exercised to render the wound and the surrounding parts aseptic. The skin should be sterilized and the wound irrigated with a 1 to 2000 bichloride solution. If the posterior tibial artery has been injured, it should be secured by ligatures, loose fragments of bone being removed, and free drainage secured by passing a large drainage-tube through the wound and bringing it out through a counter-opening upon the opposite side of the joint. Having reduced the displacement, the foot should be brought into position—that is, at a right angle to the leg. In some cases where the lower end of the tibia projects from the wound, it is often difficult to reduce the dislocation. Here resection of the tibia or excision of the astragalus renders the reduction easy, and the ultimate result as regards function is good. If the case is compli-

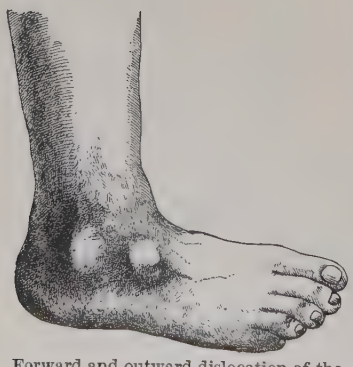
cated by a fracture of the lower portion of the tibia, it is better to excise a portion of the bone before attempting reduction, which facilitates the reduction and at the same time relieves tension and favors free drainage. We have seen the most satisfactory results in these cases follow partial excision. If the wound is an extensive one, a few sutures may be introduced at each extremity of the wound, but, as the greatest safety is in free drainage, it is wise to allow the wound practically to remain an open one. A sterilized or antiseptic gauze dressing should next be applied to the wound, and over this a number of layers of sterilized or bichloride cotton. If there is much difficulty in reducing the deformity, or if there is a tendency to redisplacement after reduction, by the muscles acting through the tendo Achillis, this tendon may be divided subcutaneously. After applying a gauze dressing, lateral splints of binders' board, moulded to the foot and leg, holding the foot at a right angle to the leg, should be applied, the foot and leg being placed in a fracture-box. An equally satisfactory dressing consists in the application of a plaster of Paris bandage including the foot and leg and extending a little distance above the knee. At the end of three or four days the splints should be removed, or the plaster of Paris bandage should be fenestrated and the wound inspected, and if it has remained aseptic the drainage-tube may be removed and the dressing reapplied. If suppuration occurs, the drainage-tube should be allowed to remain in place for some time, and irrigation and more frequent dressings of the wound will be required. In cases in which the wound runs an aseptic course and healing takes place promptly, very good functional results may be expected. Where, however, suppuration occurs, the time of repair is very much prolonged, and more or less fixation of the ankle-joint is apt to result, which may be permanent.

DISLOCATION OF THE ASTRAGALUS.

The astragalus may be dislocated forward, backward, or laterally, or rotated on its axis.

Forward Dislocation of the Astragalus.—This may be complete or incomplete, and usually results from a fall from a height upon the foot. In this dislocation there is an irregular-shaped prominence in front of the ankle, the foot is usually inverted, and the external malleolus is prominent. (Fig. 538.) **Treatment.**—In reducing this dislocation the leg should be flexed upon the thigh, to relax the gastrocnemius and soleus muscles, extension and counter-extension should be made from the foot and leg, and the surgeon should endeavor by manipulation to press the astragalus back into its normal position; if this cannot be accomplished, it may be necessary to divide the tendo Achillis, which will often facilitate the reduction of the displaced bone. If reduction cannot be accomplished by these means, the displaced bone should be exposed by incision and

Fig. 538.



Forward and outward dislocation of the astragalus.

excised. After the reduction or excision of the bone a moulded pasteboard splint should be applied for a few days, and when the swelling has subsided a plaster of Paris bandage should be applied.

Backward Dislocation of the Astragalus.—In this accident the astragalus is forced posteriorly from its position between the malleoli, and separated from the os calcis and the scaphoid. This displacement is produced by force acting upon the anterior part of the ankle when the tarsus is strongly flexed upon the bones of the leg. In this dislocation there is a prominence above the heel, the foot is shortened, and there is undue prominence of the tendo Achillis over the displaced bone. **Treatment.**—Attempts to reduce this dislocation have often proved unsuccessful, and cases have recovered with a fairly useful limb with the bone still out of place. Efforts should, however, always be made to accomplish reduction. The patient being anæsthetized, and the leg being flexed upon the thigh, extension and counter-extension should be made, and by pushing the bones of the leg backward and drawing the foot forward the dislocation may sometimes be reduced. If these manipulations fail, the displaced bone should be exposed by incision and excised.

Lateral Dislocations of the Astragalus.—Lateral dislocations of the astragalus are frequently associated with fracture of either the external or the internal malleolus. In these dislocations the foot may be inverted or everted. **Treatment.**—They are reduced by the same procedures that are employed in the backward and forward dislocations, and the after-treatment is similar.

Dislocation of the Astragalus by Rotation.—This is a rare form of dislocation of the astragalus. It is produced by the patient falling from a height upon the foot, the foot rotating while the leg is fixed. The astragalus occupies its position between the malleoli, but the relations of its articular surface are changed. The bone may be turned vertically or transversely. There is fixation at the ankle, with more or less change in shape, produced by the rotation of the astragalus. **Treatment.**—Attempts should be made to reduce this displacement by making extension and counter-extension, if necessary dividing the tendo Achillis subcutaneously and then attempting to replace the bone by manipulation. This often proves impossible, and excision of the astragalus may be required.

Sub-Astragaloid Dislocation.—This is extremely rare, and consists in a separation of the calcaneum and the scaphoid from the astragalus. The displacement of the bones may be backward, forward, outward, or inward. Fractures of the astragalus and of the external malleolus have been observed in connection with it. **Symptoms.**—In this dislocation the foot is inverted or everted, according as the displacement is outward or inward, and the astragalus is prominent in front of the ankle. Shortening or lengthening of the foot would be observed in backward or forward dislocation. **Treatment.**—The patient should be anæsthetized, and extension and counter-extension made, and with manipulation at the same time it may be possible to reduce the deformity.

Compound Dislocations of the Astragalus.—Compound dislocations of the astragalus are serious injuries, and usually result from falls

from a height, the weight of the body striking upon one foot. The astragalus may be completely driven from between the malleoli, or may be only partially displaced. **Treatment.**—In these dislocations the most satisfactory method of treatment consists in enlarging the wound and excising the displaced bone, and after the removal of the bone the foot should be placed at a right angle to the bones of the leg, a copious antiseptic or sterilized gauze dressing should be applied, and the ankle fixed for a few weeks by the application of a binders' board splint or a plaster of Paris dressing.

Dislocation of the Os Calcis.—This bone is very rarely dislocated, but may be separated from the astragalus above and from the cuboid bone in front. **Symptoms.**—The symptoms are distortion of the heel and inability to abduct or adduct the foot. This dislocation usually results from falls upon the heel, or from force applied to the bone at the side of the foot. **Treatment.**—The displacement is not difficult of recognition, and should be treated by first anæsthetizing the patient and then relaxing the muscles and reducing the displacement by manipulation.

Dislocation of the Scaphoid.—This dislocation is also extremely rare, and can be recognized by its projection on the anterior surface of the foot. **Treatment.**—It is reduced by manipulation, by making traction upon the metatarsus, at the same time pressing the bone back into its normal position. After reducing the displacement the foot should be fixed with a binders' board splint or with a plaster of Paris dressing.

Dislocation of the Cuboid.—The cuboid bone has been dislocated in connection with displacements of other bones of the tarsus, but no cases of independent luxation of this bone have been recorded. From the position of the bone, if this dislocation occurred there would be little difficulty in recognizing the nature of the injury.

Dislocation of the Cuneiform Bones.—The cuneiform bones may be dislocated separately, or the three bones may be dislocated together. The internal cuneiform bone is the one most liable to dislocation. There is a prominence on the inner border of the foot, consisting of one or more of the bones. The dislocation is reduced by carrying the metatarsal bones outward when the ankle is fixed, so as to increase the space between the scaphoid and the metatarsal bone of the great toe. After this is done the displaced bones should be pressed into place, and the foot and ankle fixed by the application of a moulded splint or a plaster of Paris bandage.

Dislocation of the Metatarsal Bones.—Dislocations of the metatarsal bones are not common, but are occasionally seen. The direction of the dislocation may be upward, downward, or lateral. They may result from falls or from the foot being caught and twisted between heavy weights. **Symptoms.**—The symptoms in these dislocations are a prominence upon either the dorsal or the palmar aspect of the foot, and shortening of the toes corresponding to the displaced bones. **Treatment.**—The reduction is effected by making traction upon the displaced bone from the toe and at the same time pressure over the end of the bone. After reduction a compress should be applied over the seat of the displacement, and the foot fixed by a splint or a plaster of Paris bandage.

Dislocations of the Phalanges of the Toes.—These dislocations are not so common as dislocations of the phalanges of the fingers, but are occasionally seen, and result from twists and extreme flexion. **Symptoms.**—The symptoms of dislocation of the phalanges of the toes are a prominence at the articulation and shortening of the injured toe. **Treatment.**—The reduction of dislocation of the phalanges of the toes is accomplished by extension and counter-extension with manipulation. After the reduction the part should be fixed by the application of a moulded binders' board gutter, which should be retained for several weeks.

DISEASES OF JOINTS.

SYNOVITIS.

Synovitis consists in an inflammation of the synovial membrane of a joint, may arise from local causes, such as sprains and contusions, or from infective or tubercular inflammation of the bones and cartilages of the joints, or from constitutional causes, such as gout or rheumatism. It may exist as an acute or as a chronic affection.

Acute Synovitis.—This affection may result from contusions, sprains, twists, wounds, exposure to cold or dampness, infective processes, or rheumatism. The synovial membrane becomes injected and œdematous, and its secretion is increased in amount, and may be thin and watery or, from excess of fibrous exudations, flocculent or purulent; the joint at the same time becomes distended from the excess of secretion.

Symptoms.—The prominent symptoms of acute synovitis are pain, increased by motion of the joint or by pressure upon the articulation, and swelling, which changes the normal shape of the joint; there may also be more or less flexion of the joint as a result of the intra-articular effusion. Fluctuation is usually marked in the region of the joint in which the capsule is thinnest. The skin is hot to the touch, but is often unchanged in color. Elevation of temperature is usually present, the degree of elevation depending upon the size of the joint, the acuteness of the attack, and its cause. In acute septic synovitis chills occur, and are accompanied by a septic temperature; the swelling of the joint increases, and the skin becomes œdematous and red, pointing to the presence of pus within the joint.

Treatment.—The first indication in the treatment of acute synovitis is to place the joint at rest by the application of a splint, and it is often more comfortable to the patient if the joint is fixed in a semi-flexed position. Cold should then be applied by means of an ice-bag, and this may be followed by the use of a lotion, such as lead water and laudanum. If the distention of the joint is great, and it is likely that the vitality of the synovial membrane and cartilages is threatened, the joint should be aspirated with full antiseptic precautions. This procedure quickly relieves the distention, and hastens the cure of the case. When the acute symptoms have subsided, the use of elastic pressure by means of a rubber bandage, or the application of tincture of iodine or massage, will often be followed by good results. Acute synovitis in healthy subjects rarely terminates in suppuration, but in debilitated subjects such a termination may occur. If, in spite of treat-

ment, acute synovitis runs on to suppuration, the joint should be opened by incisions and washed out with a 1 to 2000 bichloride solution, free drainage being secured by the introduction of drainage-tubes. Even if suppuration has occurred, if free drainage is secured before the surfaces of the cartilages have become ulcerated, recovery may take place with little loss of function in the joint.

Chronic Synovitis.—This may result from acute synovitis, or may arise from trivial causes and occupy a considerable time in its development. In chronic synovitis there is usually more or less involvement of the other structures of the joint, giving rise to arthritis. The synovial membranes become œdematous and thickened, and may be thrown into folds or may be fastened together by adhesions from organization of the exudations between their surfaces. Fluid in variable quantity may exist in the joint, and patches of membrane undergo degeneration and softening, or may become studded with villous growths, or suppuration may eventually occur.

Symptoms.—In chronic synovitis there is generally marked limitation in the motion of the joint; pain is usually absent unless pressure is made upon the joint or motion of the joint is attempted. The shape of the joint is changed, depending upon the amount of effusion and the thickening of the tissues. If the amount of effusion is large, the condition known as *hydrops articuli* is present. In dry cases motion of the joint will develop crepitation or crackling. Wasting of the muscles in the region of the joint from disuse is usually very marked.

Treatment.—The treatment of chronic synovitis consists in fixation of the joint and the adoption of means which favor the absorption of the plastic exudates and fluid. The use of tincture of iodine or pressure over the joint is often followed by good results. The application which we have seen give the best results is one composed of—ungt. iodi, ʒii; ungt. belladonnæ, ʒvi; ungt. hydrargyri, ʒii. This should be spread upon lint and applied over the surface of the joint, which should be fixed by the application of a splint or a plaster of Paris dressing. After the swelling has subsided, passive motion and massage should be employed. In cases in which a large amount of effusion is present, aspiration of the joint may be of service. In long-standing cases aspiration and irrigation with a five per cent. solution of carbolic acid, of which from five to ten cubic centimetres are allowed to remain in the cavity, may be practised with good results. Many months of treatment are often required before the patient regains fair use of the joint. If abscesses form they should be opened and drained, and in cases of extensive disorganization of the articulation excision or amputation may ultimately be required.

ARTHRITIS.

This consists in an acute or a chronic inflammation involving the joint as a whole, which may arise from a traumatic synovitis or from the presence of pyogenic cocci, or may be due to infection from special organisms, such as the bacilli of tuberculosis, or the micro-organisms of gonorrhœa or typhoid fever, or may develop as a complication of rheumatism, gout, syphilis, or diseases of the nervous system.

Acute Septic Arthritis.—Abscess of a Joint.—This affection may result from a penetrating wound of a joint, the pyogenic organisms gaining access to the joint through the wound, or in cases of osteomyelitis by extension of the infective process through the articular ends of the bone or periarticular structures, or in patients suffering from pyæmia through the infection of the synovial membrane by the micro-organisms in the blood. An extra-articular abscess may also rupture into a joint and cause this affection. The pathological lesions consist in exudation into the synovial sac, the subsynovial connective tissue, and the capsule and ligaments of the joint, and the free formation of pus. The articular cartilages become softened and broken down, or may be separated in masses from the bone. The ligaments may also become softened and eroded, so as to permit of undue motion or displacement of the bones.

Symptoms.—The joint becomes swollen and painful, the pain being increased by motion and being worse at night. The skin becomes hot, red, and œdematous, fluctuation may be obtained, and intra-articular tension is shown by flexion of the joint. Constitutional symptoms are manifested by a chill or chilliness; fever is present, the temperature often being as high as 104° to 106° F. (40° to 41° C.); the pulse becomes rapid, the patient presents the constitutional symptoms of septic intoxication, and death may result in three or four days from septicæmia. In cases of septic arthritis due to pyæmia the swelling of the joint is preceded by the constitutional symptoms of pyæmia; there may be no pain, and swelling of the joints may be the most prominent symptom. A number of joints are usually involved. Septic arthritis is a very serious affection, and if not promptly treated is apt to terminate fatally in a few days.

Treatment.—This consists in making free incisions into the joint, followed by thorough disinfection of the joint-cavity. This is best accomplished by antiseptic irrigation with a 1 to 2000 bichloride solution and the introduction of drainage-tubes. A copious antiseptic gauze dressing should next be applied, and the joint immobilized by the application of a splint. After disinfection and free drainage of the joint have been accomplished, the constitutional disturbance usually subsides rapidly, and the discharge from the joint gradually diminishes. If the joint has been opened early, recovery with more or less restoration of function may take place. In other cases, where extensive disorganization of the joint has occurred, sinuses may persist, and necrosis or caries of the articular ends of the bones, with relaxation of the ligaments, may be present. In such instances the joint is useless, and an arthrectomy or excision may be required, and rarely amputation is called for. In pyæmic cases the prognosis is not so favorable, as the patient often succumbs to the septic infection; but even in these incision and drainage of the joints are sometimes followed by recovery.

Infective Arthritis.—This disease, which presents many points in common with septic arthritis, may arise in the course of acute infective diseases, such as erysipelas, scarlet fever, measles, and small-pox, and is due to infection of the joint by pyogenic cocci or by the specific micro-organisms of the particular disease. In this form of arthritis the joint affection arises from the infection of the synovial membranes by pyogenic or

specific organisms in the blood, or by their ptomaines. In infective arthritis the joints may become painful, red, and swollen, and yet suppuration may not take place. In other cases suppuration may occur in the joint, and the conditions presented will then be very similar to those observed in septic arthritis.

Treatment.—In the early stages of this form of arthritis, if there is no evidence of suppuration, lead water and laudanum should be applied over the surface of the joint, or it may be enveloped in cotton wadding, and a bandage applied firmly over this dressing, the part being fixed by the application of a splint. Under this treatment in many cases resolution takes place in a few days, and recovery follows with a good functional result. If, however, suppuration occurs, as shown by swelling, redness, and œdema of the overlying skin, with distention of the joint and the occurrence of a chill, the joint should be freely opened and irrigated with a 1 to 2000 bichloride solution, drainage-tubes or gauze strips being introduced, and after applying a copious antiseptic dressing it should be fixed by a splint.

Gonorrhœal Arthritis—Gonorrhœal Septicæmia.—During the course of acute or chronic gonorrhœa there may develop a synovitis or an arthritis, with effusion into the joints, due to infection by the gonococcus of Neisser, or to a mixed infection from gonorrhœal and pyogenic organisms. Men are more apt to suffer from the affection than women, and the joints most commonly involved are the knee and the ankle; occasionally the intervertebral, sterno-clavicular, temporo-maxillary, and sacro-iliac articulations are affected. The presence of gonococci cannot always be demonstrated, and in such cases the infection may possibly be due to their ptomaines.

Symptoms.—In acute cases one or more joints become painful and swollen, the skin becomes red, and the joint assumes the position which relieves intra-articular tension. There are usually present more or less elevation of temperature and acceleration of the pulse. In subacute or chronic cases the joint becomes swollen and distended with fluid, and pain is not a prominent symptom. Suppuration rarely occurs, and when this accident takes place it is probably due to a mixed infection from pyogenic and specific organisms. The inflammation usually terminates in resolution, and is apt to result in more or less ankylosis of the joint from organization of the articular and periarticular exudations. In subacute or chronic cases the effusion in the joint is absorbed very slowly, weeks or months often being required.

Treatment.—Attention should be given to the cure of the coexisting urethritis. While there is any evidence of inflammatory symptoms the joint should be immobilized by the use of a splint or a plaster of Paris dressing. If pain is a prominent symptom, a lotion of lead water and laudanum may be applied with good results; the use of an ointment of belladonna and mercury, equal parts, or of ichthyol is often satisfactory. As soon as the pain has disappeared, gentle passive motion should be practised, but if this is followed by pain and swelling it is an evidence that immobilization of the joint should again be resorted to, and passive motion and massage should be postponed for a time. In chronic cases with large effusion into the joint, aspiration and irrigation with a five per cent. carbolic solution, with full antiseptic precautions, may be practised, and followed by massage. If ankylosis results, the adhesions may be broken up

under an anæsthetic, but there is always the risk that forcible motions of the joint may set up fresh inflammatory action, so that we are disposed to think it is better to leave the patient with an ankylosed limb in good position, if not painful, than to attempt to restore motion by violent manipulations, which may be followed by extensive inflammation of the joint. The administration of iodide of mercury, grain one-third, combined with extract of hyoscyamus, grain one-half, three or four times a day, is often followed by good results. Internally opium may be required to relieve pain, and salol, the salicylates, oil of wintergreen, and quinine may be employed.

Syphilitic Arthritis.—Synovitis or arthritis may develop as the result of syphilis, either in the early secondary stages, when it may be of the nature of a subacute septic synovitis, or in the later secondary stages of the disease, either in acquired or in congenital syphilis. In the later form the pathological change consists in a small-celled infiltration or a diffused gummatous formation.

Fig. 539.

Syphilitic arthritis.

Symptoms.—Pain is not usually a prominent symptom, even when the joint disease is marked; muscular spasm may be well developed. The joint is not uniformly swollen, but is apt to present several points of enlargement, which give an elastic, doughy feeling; the skin is not red or inflamed, but later the skin covering the swelling may become purple or brown. (Fig. 539.) When these conditions of the joints are associated with other signs of syphilis, the diagnosis of the character of the joint-lesion is not difficult; but in other cases the diagnosis of this affection from tuberculosis of the joints is often impossible.

Treatment.—The results of treatment in syphilitic synovitis and arthritis are usually satisfactory; immobilization of the joint is seldom necessary, and the patient may be allowed to use the part moderately. The local use of mercurial ointment or plaster over the joint is often followed by good results. In young subjects, and especially in congenital cases, biniodide of mercury or the bichloride in appropriate doses, continued for some time, is often followed by the best results. In older subjects, or even in young subjects, after mercurials have been used for some time, the administration of iodide of potassium alone, or the mixed treatment, biniodide of mercury, grain one-twenty-fourth, iodide of potassium, grains five to ten, will often be followed by rapid diminution of the joint affection. As anæmia

is usually associated with this condition, iron in some form should be administered, the iodide being especially useful.

Rheumatic Arthritis.—This form of arthritis may be acute or chronic. Acute rheumatic arthritis usually attacks a number of joints at the same time, and is characterized by the same symptoms as acute synovitis,—pain, tenderness on pressure or motion, heat, swelling, elevation of temperature, and increase in the pulse-rate. This form of arthritis is a local manifestation of a general disease, which usually ends in resolution without producing any marked structural change in the joints involved or any loss of function, and is more likely to come under the care of the physician than of the surgeon. Monarticular rheumatism is most likely to be confounded with acute arthritis.

Chronic Rheumatic Arthritis.—This affection may result from repeated attacks of acute rheumatism, or may occur in persons who are constantly exposed to cold, dampness, or privation. There are marked alterations in the joint structures, the synovial membranes and the periarticular structures becoming thickened, and the secretion of synovial fluid is diminished; the cartilages are occasionally eroded, and the joint becomes stiff and painful. Upon motion of the joint crackling or crepitation may be elicited. In some cases plastic exudation binds together the articular and periarticular structures, so that restriction of motion or ankylosis results. Wasting of the muscles is very common.

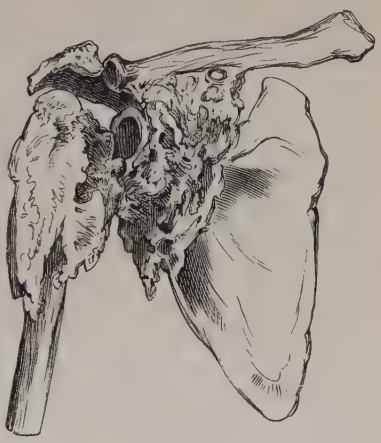
Treatment.—The treatment in this affection is directed to promoting the absorption of the exudations and adhesions, and then as far as possible restoring the function of the affected joints. The patient should wear woollen clothing, and avoid exposure to cold and dampness. The administration of salicylates, iodide of potassium, and the salts of lithium should be resorted to, and iron, arsenic, and strychnine may be employed with advantage. Massage and electricity are of service, and ankylosis may be overcome by motions of the joint under an anæsthetic. When there is marked contraction of the joints, tenotomy may be required to correct the deformity.

Gouty Arthritis.—This form of arthritis occurs in patients of a gouty diathesis, and attacks especially the smaller articulations, such as those of the fingers and toes and the metacarpal and metatarsal joints. There is a deposition of urate of sodium in the connective tissue of the joint and the periarticular tissues, which results in destruction of the cartilages, alteration in the shape of the joint, and impairment of motion. The irritant action of the urate of sodium results in overgrowth of the connective tissue and the production of fibrous tissue, which contracts and causes deformity of the joint. From the accumulation of urate of sodium in the joints chalk-stones form, which may cause ulceration of the skin over them. In gouty subjects acute exacerbations occur, and the affection usually involves one or more joints, which become hot, swollen, and painful, the metatarsophalangeal joint of the great toe being the one most commonly involved. Gouty arthritis is simply the local manifestation of a general disease which comes under the province of the physician, but the occurrence of contraction and deformities of the joints may require surgical treatment.

Osteo-Arthritis (Arthritis Deformans).—This is a disease of later life, and is rarely seen in subjects under fifty years of age, although it occa-

sionally develops in feeble individuals under this age; it is more common in women than in men. It appears to arise from loss of vitality of the tissues, possibly dependent upon trophic nerve-changes, which lead to defective innervation. In the early stage of this affection the articular cartilages appear roughened and fibrillated, and finally there is an actual loss of substance in the cartilage; later there is swelling of the edges of the cartilage, with the formation of nodules, and masses of cartilage may become detached, forming loose bodies in the joint; still later the bone becomes hyperæmic, and osseous tissue is thrown out around the periphery of the joint, the latter condition producing great deformity and interfering seriously with its motions. (Fig. 540.)

Fig. 540.



Osteo-arthritis of the shoulder-joint. (Agnew.)

Symptoms.—The symptoms which distinguish this affection from other varieties of arthritis are slowness in the development of the articular changes, absence of pain or of elevation of temperature, grating upon movement, enlargement and distortion of the joints, and muscular atrophy. In young persons the disease may present a more acute type. In some cases one joint only is affected, especially in elderly persons, in whom the hip may be involved, giving rise to the affection known as *morbus coxæ senilis*, or the vertebral articulations may be involved, producing stiffness and deformity of the spine.

Treatment.—The treatment of this affection is, upon the whole, unsatisfactory, although in the early stage of the disease it may retard the development. All depressing influences should be removed, and the nutrition of the patient should be improved by the administration of cod-liver oil and arsenic; iodide of potassium and iodide of iron may often be employed with good results. Ankylosis of the joints should be prevented by careful passive motion, and massage is of great service in hastening the absorption of effusions and in improving the nutrition of the muscles and tissues in the region of the diseased joints.

Periarthritis.—This is characterized by a subacute or chronic inflammation of the deeper structures surrounding a joint, and is accompanied by less swelling and constitutional disturbance than accompany inflammation of the joint itself. It is rare in children, but is common in adults. The diagnosis from ostitis is made by observing that a distinct grating may be felt upon moving the joint. A single joint usually is involved, unless the affection be of rheumatic origin. **Treatment.**—This consists in rest of the joint for a time if pain is a prominent symptom, and later motion, under anæsthesia, and the use of massage and passive motion to restore the function of the joint.

Neuropathic Arthritis.—Charcot's Disease.—This is a peculiar form of osteo-arthritis, which has been described by Charcot, presenting

many of the symptoms of arthritis deformans, and occurring in patients suffering from locomotor ataxia. The disease is more acute in its course than the ordinary osteo-arthritis, and affects the larger joints, particularly the knee-joint. **Symptoms.**—The disease begins acutely with an effusion into the joint, which is unaccompanied by pain or elevation of temperature, and soon undergoes absorption or organization; later degeneration of the articular cartilages, periarticular structures, and bone occurs, and there is often great enlargement of the ends of the bones by osteophytes, very similar to those seen in osteo-arthritis. Grating of the joint upon motion is present, and relaxation and degeneration of the ligaments often give rise to great mobility or partial or complete dislocation of the joint. Rapid muscular atrophy is observed at the same time. Degeneration of the bones in the region of the joint may cause fracture upon slight provocation. **Treatment.**—The treatment for this condition is that appropriate for locomotor ataxia, the joint at the same time being protected by the application of a splint or apparatus which serves to limit the motion and prevent displacement.

Hysterical Affection of Joints.—This affection consists in a painful condition of the joints, and is most commonly seen in young women; the joints most frequently affected are the hip and the knee. It may arise after a slight injury or sprain of the joint, or without apparent cause.

Symptoms.—The patient complains of pain in the joint and refuses to move it; the overlying skin is hyperæsthetic, there is no marked swelling, and the joint may be maintained in a position of flexion or extension, although it is generally observed that the amount of flexion or extension is changed from day to day, and the flexion is not like that which is common in arthritis. Muscular atrophy is present from disuse. Superficial pressure produces evidence of extreme pain, while deep pressure is often painless. Fixation of the joint is usually quickly overcome if the patient is anæsthetized; the patient at the same time often exhibits other symptoms of hysteria.

Treatment.—The treatment of this affection often requires the greatest judgment and skill upon the part of the surgeon. The constitutional condition of the patient should receive as much attention as the affected joint. The general health should be carefully looked after, tonics often being indicated, and the surgeon should endeavor to make the patient understand that the condition is one which will soon improve under treatment. We have found in these cases the best results follow the use of Paquelin's cautery, the point being lightly passed over the skin of the joint at a number of points, and after a few applications of this nature massage and passive motion should be employed; at the same time tonics are administered, and the patient is encouraged to make use of the joint; no dressing further than a simple flannel bandage is indicated. In obstinate cases, in addition to the remedies above recommended, the removal of the patient from her surroundings and from the attention of sympathizing friends is advisable. The rest treatment of Weir Mitchell will often be followed by a rapid improvement, both in the local and in the constitutional condition of the patient.

Neuralgia of Joints.—The joints are occasionally the seats of pain which appears to be independent of a change in the structure of the joint. Such neuralgic pain may arise from neurasthenia, from malaria, from disease

of the brain or of the spinal cord, or from injury of or pressure upon the trunks of nerves supplying the joint.

Symptoms.—The pain is usually intermittent, and is often observed in joints which have received a previous injury, such as a sprain or contusion, although the function may have been completely restored. The patient complains of burning or lancinating pain, which is apt to be most severe at the end of the day, when he is more or less exhausted. There is no swelling or deformity of the joint, and the overlying skin appears normal.

Treatment.—When neuralgia of a joint follows an injury and there is more or less fixation, the patient should be anæsthetized and passive movements made to break up articular or periarticular adhesions, and the subsequent use of the joint should be encouraged. This treatment is usually followed by complete relief of the painful symptoms. If the condition can be traced to injury of or pressure upon a nerve-trunk supplying the joint, nerve-stretching or neurectomy should be practised. When no tangible cause for the painful condition of the joint can be determined, the patient should be placed upon tonic treatment, and, as in the case of hysterical joints, we have found good results follow the use of Paquelin's cautery, the point being lightly passed over the joint; massage and electricity may also be employed with advantage.

Neoplasms of Joints.—The joints are rarely the seats of primary growths, such as sarcomata, carcinomata, or chondromata. Secondary invasion of the joints, however, occurs frequently. Sarcoma originating in the head of a bone may extend towards the joint and stretch or distort the articular cartilages, or rupture them and invade the joint. Chondromata growing from the bones, the periosteum, or the soft parts may also involve the joints secondarily. Carcinoma as a secondary affection of joints is among the rarest of diseases.

Treatment.—In cases of neoplasms of joints the only treatment which offers the patient relief is amputation.

Cysts of Joints.—These growths usually are connected with synovial sacs in or about the joints, and result from the dilatation of normal bursæ by excessive secretion. The treatment of cysts of joints is considered under Bursitis.

Loose Bodies in Joints.—Loose bodies, consisting of fibro-cartilage, bone, or fibrous material, are occasionally observed in the larger joints, the knee-joint being most frequently affected, and next in frequency the elbow-joint. They may be loose in the joint, or attached by a long or a short pedicle. They vary in size from that of a pea to an inch or more in diameter. (Fig. 541.) These bodies originate from the synovial fringes of the joint, becoming detached and remaining free in the joint, or from detached osteophytes, or portions of bone or cartilage, resulting from injury, or from quiet necrosis, by which process a portion of cartilage is detached from the subjacent bone without suppuration. Fibrous bodies probably result from the organization of blood-clot which has been present in the joint.

Symptoms.—A patient who has never received an injury to his knee may suddenly be seized with severe pain in the joint and feel that he is unable to move it in any direction; at the same time he may complain of

nausea, and may even vomit; the joint becomes fixed and soon shows evidence of synovitis. The disability may last for a few days, and usually suddenly disappears as the loose body changes its position. The patient often experiences no further difficulty for months, but is likely to have a repetition of the same symptoms if the body again becomes wedged between the articular surfaces of the joint. During the interval he may be conscious of the body slipping about in the joint or in the bursæ connected with the joint, and it can often be felt at certain points, but usually quickly disappears if pressure is made upon it. Flexion and extension of the joint may again dislodge it. Patients are often able, by certain motions of the joint combined with pressure and manipulation, to dislodge the body, when it can be felt under the skin in the region of the joint. Sooner or later synovitis develops, and as a result of the stretching of the ligaments the joint becomes weak.

Fig. 541.

Loose bodies from the knee-joint. (Agnew.)

Treatment.—The body may be kept in place by the use of a bandage firmly applied over the joint, or by wearing a close-fitting laced knee-cap. If, however, the patient experiences pain and frequent attacks of disability, if the body can be located the most satisfactory treatment is its removal by incision. As the body often slips out of view before the incision is made, it should be transfixed with a needle and the incision made directly down upon it. The risk of this operation, if proper care is taken as regards asepsis, is small. After the removal of the body the wound should be closed by deep sutures uniting the edges of the wound in the capsule, and finally by a layer of superficial sutures approximating the skin and connective tissue, a gauze dressing applied, and the joint kept at rest for a few weeks upon a splint or by a plaster of Paris dressing.

Displacement of the Semilunar Cartilages of the Knee.—A semilunar cartilage may become loosened from its capsular attachment and move in between the tibia and the femur, becoming wedged between the articular surfaces. This may occur in a healthy joint, or in one in which synovitis or osteo-arthritis exists. The cartilage may be entirely detached from the tibia, and may become wedged between the articular ends of the bones, causing locking of the joint. A patient who has once suffered from displacement of a semilunar cartilage is likely to have a recurrence of the displacement.

Symptoms.—When this accident occurs the leg becomes suddenly partially flexed and the knee-joint locked; the patient complains of severe pain in the knee, and is unable to bear his weight upon it; at the same time he may suffer from nausea and vomiting. Some swelling of the joint may follow the accident, but quickly subsides after the cartilage is replaced.

Treatment.—The replacement of the cartilage can usually be accomplished by flexing and extending the knee-joint, at the same time making rotation. As the muscles hold the knee very rigidly and the manipulations are painful, it may be necessary to give an anæsthetic. Patients who fre-

quently suffer from this accident soon learn to replace the cartilage themselves, by bearing their weight upon the flexed knee and suddenly transferring the weight of the body to the other leg and extending the knee of the injured leg. If, however, it is impossible to replace the detached cartilage, or if the accident is of such frequent occurrence as to cause constant disability, operative treatment should be instituted. The joint should be opened by an incision, the greatest care being taken to make the operation an aseptic one, and the detached cartilage exposed and removed, or sutured again to the edge of the tibia with silk or kangaroo tendon sutures, the wound in the capsule of the joint being closed with sutures, as well as the external wound. After dressing the wound the leg should be placed upon a posterior splint to fix the knee-joint, or a plaster of Paris dressing applied. Fixation of the joint should be maintained until the wound is solidly healed.

Ankylosis.—This condition, which consists in the partial or complete obliteration of the motions of a joint, results from alteration of the surfaces of the joint from disease; disuse in the larger joints is not capable of producing complete ankylosis. Ankylosis may be either fibrous or bony; the former arises from the removal of the superficial layer of the articular cartilages by ulceration and the deposit of plastic material; while the latter always results from the complete destruction of the articular cartilages, so that the ends of the bones come in contact and unite. Ankylosis of a joint may also result from *periarthritis.*

Ankylosis of a joint may result from wounds involving a joint followed by suppurative arthritis, or from the organization of effused blood in the joint, the latter producing only fibrous ankylosis, or from acute or chronic arthritis accompanied by destruction of the articular cartilages, producing bony ankylosis. Ankylosis of joints may occur in such positions that the limb is absolutely useless, or may take place with the limb in such a position that the part can be of use to the patient. In fibrous ankylosis there is always a fair chance that the motions of the joint may be regained; in cases of bony ankylosis it is impossible to have restoration of joint motion.

Treatment.—In the treatment of ankylosed joints the surgeon has an opportunity to exercise great surgical judgment. In cases of stiffness of joints from disuse, such as is frequently found after prolonged fixation of joints in the treatment of fractures, where there is no true ankylosis, passive motion and massage should be employed, and will usually be followed by the restoration of function.

In fibrous ankylosis with the limb in bad position, following contusions or wounds of joints, where the ankylosis is probably due to intra- and periarticular fibrous bands, an anæsthetic should be administered and forcible movements of the joint made to break up adhesions, and, after putting the joint at rest for a few days, passive motion should be carefully practised. If the cases are of long standing and the contraction is marked, the surgeon should remember the possibility of contracture of the important blood-vessels and nerves, which may be torn if forcible movements of the joint are made in straightening the limb. In such excision of the joint is preferable. In cases of fibrous ankylosis of joints in good position as regards their usefulness, and of fibrous ankylosis resulting from tubercular

arthritis, no forcible movements should be practised, as fresh inflammation may be excited and subsequent destruction of the joint may occur. In bony ankylosis with the joint in good position, the treatment depends upon the joint involved; at the knee-joint ankylosis with the limb nearly straight is a condition which cannot be improved upon by operation; the same may be said of the hip- and ankle-joints. Here attempts to restore joint motion by forcible movements are useless, and may result in fracture of the bone, which may occur at the position of the former articulation or at any other point.

In the joints of the upper extremity, the shoulder and elbow, for instance, the loss of motion interferes so much with the patient's means of livelihood and comfort that operative treatment is indicated. In these cases excision of the ankylosed joint may be undertaken with the idea of obtaining a false joint which will increase the usefulness of the part. In bony ankylosis of joints in bad position, when the limb is useless, excision of the ankylosed joint should be practised, or an osteotomy of the bones above and below the joint may be done in some cases with satisfactory results as regards the correction of the deformity. After excision, if it is desirable to have a movable joint, as soon as the wound has healed motion should be encouraged, so that a false joint shall result. If fixation is desired, the splints should be retained until firm fibrous or bony union has occurred. The operations for ankylosis are described on pages 638 and 670.

TUBERCULOUS ARTHRITIS.

The majority of cases of chronic joint disease arise from infection by the bacillus tuberculosis. The disease may originate in the bone, the synovial membrane, the capsule of the joint, or the periarticular structures. The exciting cause of tuberculous arthritis may in many cases be traced to sprains, blows, twists, or exposure to cold; in other cases the disease develops without apparent exciting cause. Tuberculosis of synovial membranes is more frequent in adults, while tuberculosis of bone is more common in children. When the synovial membrane is the seat of the disease from direct infection of a joint by tuberculous matter, there are active hyperæmia of the membrane and external swelling, but when the invasion of the disease is slower the joint shows little evidence of active inflammation, the synovial membrane becomes congested, hypertrophied, and œdematous, and there is an abundant development of granulation-tissue. The tubercular infection produces a pulpy condition of the entire synovial sac, with usually little or no effusion into the joint, the swelling being entirely due to a thick layer of granulation-tissue. In this form of tuberculosis great deformity of the joints results early in the disease, such as flexion, rotation, and in some cases partial luxation. In other cases the fungous granulations are less marked, and free effusion takes place into the joint. If the primary infection takes place in the bone, the disease by direct extension of the process soon involves the structures of the joint, a portion of the cartilage is destroyed, and the joint is opened. Tuberculosis of bone in the region of a joint usually involves the synovial structure of the joint, and, on the other hand, primary tuberculous synovitis and arthritis are apt, by extension, later to implicate the subjacent bone.

Symptoms.—In a case of tubercular arthritis the marked swelling of the joint is due to the production of excessive granulation-tissue, which may undergo degeneration, becoming softened and œdematous, and the appearance of the joint changes, becoming spindle-shaped, as the softened ligaments offer little resistance to the growing granulations. The skin over the joint is white and thickened, and palpation will often elicit a sensation of fluctuation, which is present only when the synovial sacs are distended with serous effusion or pus. Pain in synovial tuberculosis is usually slight, but may be more marked in the joint tuberculosis which originates in the bone; it may be elicited by pressure or by certain motions. The temperature of the patient may be slightly elevated, and the joint may feel hot to the touch. Deformity is present in all cases to a greater or less degree, depending upon the joint involved, the extent of softening and degeneration of the ligaments, the tendency to assume certain attitudes to secure relief from pain, and muscular spasm induced by reflex irritation. Muscular spasm is one of the first and most important symptoms of joint tuberculosis, and consists in a reflex muscular spasm, which is manifested by an unconscious automatic contraction of the muscles, producing rigidity and fixation of the joint. Impairment of joint motion may be slight at first, but as the disease advances it becomes a prominent symptom. Caseation and liquefaction of the granulations covering the synovial membrane may occur, and the pus, so called, accumulates in the cavity of the joint, and finally perforates the capsule, forming sinuses. During this process the granulations are destroyed, the tubercle bacilli penetrate the deeper tissues, and the patient is exposed to the risks of general tubercular infection. If upon spontaneous or intentional opening of such a joint pyogenic organisms enter the joint, there is aggravation of the local condition of the diseased joint and of the patient's constitutional condition.

Pannus Synovitis.—In this form of synovitis or arthritis the tubercles are present in great numbers widely disseminated over the synovial membranes, but are rarely visible to the naked eye. From the border of the articular cartilages a thin layer of granulations approaches the centre of the joint, the vascularity of the membrane is marked, and the ligaments and periarticular structures are but slightly affected. There is sometimes a large serous effusion in the joint.

Diagnosis.—The diagnosis between primary osteal and primary synovial tuberculosis is often a matter of difficulty. In cases of the fungous variety of the disease involving superficial joints, if well advanced, and if it has gone on to the formation of abscess or sinus, the recognition of the disease is not difficult. This joint affection may be confounded with syphilitic arthritis, with which it has some points in common, but the latter affection is quite rare, except in children, and careful examination will often show other evidences of syphilis. In primary osteo-tuberculosis of joints, aside from the circumscribed points of tenderness over certain parts of the joint, if the disease is not far advanced, the loss of function, swelling, and muscular resistance may be so little marked that it will be difficult to say that the affection exists. If, however, any of the symptoms are present, the patient should be given the benefit of the doubt and treated as if joint tuberculosis were actually present.

Prognosis.—This depends largely upon the general condition of the patient and the extent of the local disease. When the disease involves only a small portion of a joint, recovery may take place with more or less ankylosis and impairment of joint function. In cases, however, in which there is marked involvement of the joint, the destruction may be so extensive that recovery can take place only with a joint in which marked restriction of motion or ankylosis is present, the fixation of the joint resulting from firm fibrous or bony ankylosis. The development of abscess or sinus may result in caries or necrosis of the articular ends of the bones. Many cases of joint tuberculosis run a course of years and finally recover with more or less impairment of motion. In tuberculosis of joints there are three distinct stages which are recognized during the course of the affection : 1, muscular spasm or rigidity ; 2, effusion or granulation ; 3, abscess.

The caseation, if extensive, is accompanied by constitutional disturbance of more or less severity, and if septic infection occurs it involves additional risks to the patient. During the course of the disease the patient is also in danger of the development of general or visceral tuberculosis, and, in cases of prolonged suppuration, of amyloid disease.

Treatment.—A spontaneous cure in cases of joint tuberculosis is rare, and if it does occur it usually results in such marked deformity of the joint that a subsequent operation has to be undertaken to render the part useful. The most important point in the treatment is to secure complete rest or immobilization and favor ankylosis of the joint, as the disease is always aggravated by movements of the joint. Early immobilization of a tuberculous joint secures perfect rest, and at the same time tends to prevent subsequent deformity. Immobilization of a joint may be accomplished by the use of orthopædic apparatus or by the application of a plaster of Paris bandage, which should be applied over a flannel bandage. The plaster bandage is often so applied that it does not completely immobilize the joint. In applying the plaster of Paris bandage to fix the knee-joint the bandage should extend from the toes to the groin ; for the ankle, the bandage should extend from the toes to the knee. To secure fixation to the hip-joint, the patient should stand with his sound limb upon a low stool, so that extension of the diseased joint is made by the weight of the limb, and the plaster bandage should envelop the limb from the toes to the pelvis, which should be surrounded by turns of the bandage, or the patient's pelvis should be supported upon an apparatus (shown in Fig. 125), extension at the same time being made upon the limb while the bandage is carried around the pelvis. In immobilizing the shoulder-joint the arm should be fastened to the side, and in the elbow the plaster bandage is applied to the arm, which is flexed to a right angle, from the wrist to the shoulder. In fixing tuberculous joints the surgeon should always bear in mind the possibility of ankylosis, and see that the joint is fixed in such a position that it will be most useful if this result occurred. Fixation of the diseased joint may also be secured by the use of moulded splints of binders' board or of felt, and by the use of mechanical apparatus, which can be so constructed that it fixes the joint and at the same time makes traction upon it so as to separate the diseased joint surfaces. The latter form of splint is one which is largely employed

in the treatment of tubercular arthritis of the hip, knee, and ankle. Fixation of the joint should be maintained for a considerable time, even after the evidences of active disease have disappeared, fixation for months or years often being required. If deformity of the joint has occurred before the case comes under the surgeon's care, this should be corrected by the application of weight extension or by tenotomy before the fixation apparatus is applied. Aspiration may be required in cases in which there is a large effusion in the joint or when a tuberculous abscess has formed. The treatment of tubercular joints by the injection of agents which favor the cicatrization of the new tissue and bring about destruction or encapsulation of the bacilli has recently been employed with most encouraging results. (See page 61.) When, in spite of rest or the injection of iodoform, the disease progresses and destruction of tissues of the joint begins, operative treatment, such as arthrectomy, excision, or amputation, is often required. The **operative treatment** of tuberculosis of the joints, arthrectomy or excision, in children may be deferred to a later period than in adults, for in the former subjects recovery with ankylosis is more likely to occur, while in adults early operation is usually required. Amputation in tuberculosis of joints is rarely demanded, but is occasionally required as a life-saving measure in cases where there is extensive disease of the joints as well as of the periarticular structures, or in cases of multiple affection of the joints of the same limb, or where the patient presents marked exhaustion from profuse suppuration or shows evidence of beginning visceral disease. Amputation is sometimes required after excision where there is no improvement in the condition of the parts after this operation. In tubercular arthritis, in addition to the local treatment just described, the patient's constitutional condition should receive most careful attention. He should be given a nutritious and easily assimilated diet, and should be in the fresh air as much as possible; sea air is often very beneficial. The drugs which are most serviceable are iron, which may be given in the form of the iodide of iron, cod-liver oil, and syrup of hydriodic acid.

DISEASES OF SPECIAL JOINTS.

DISEASES OF THE HIP-JOINT.

Simple Acute Synovitis of the Hip-Joint.—This affection is occasionally seen in the hip-joint, although, from the depth of the joint and its protection by muscles and fascia, it is not so much exposed to the causes producing it as some other joints. The condition may result from exposure to cold or from strains. **Symptoms.**—The symptoms are heat and stiffness, accompanied with pain, which is often referred to the knee, from the connection between the two joints by the obturator nerve; swelling may be noticed over the front and back of the capsule, caused by effusion into the synovial sac and by œdema. Flexion, abduction, and eversion of the thigh are also present. In the early stages of the affection the patient has a well-marked limp in walking, and later the pain and tenderness may be so great that he cannot use the limb. **Diagnosis.**—In young subjects it is often difficult to differentiate this affection from tuberculous arthritis of the hip or coxalgia, but the diagnosis can be made in most cases by observing

that it comes on soon after a strain or exposure to cold, and when proper treatment is instituted recovery soon takes place. We are inclined to think that many of the cases of coxalgia which have been reported as being cured in a short time by the use of splints or special apparatus, in which recovery followed without deformity and impairment of function of the joint, were really cases of acute simple synovitis of the hip.

Treatment.—The first indication in the treatment of simple acute synovitis is to put the joint at rest. This may be accomplished by confining the patient to bed and applying extension by means of a weight and pulley attached to an extension apparatus applied to the leg, such as is used to make extension in fractures of the femur; lateral support may also be given to the limb by the use of sand-bags. The same object may be accomplished by the use of Thomas's or Taylor's splint in case it is desirable to allow the patient to go about during the course of treatment. In infants and young children fixation may be secured by the application of a splint of felt or binders' board moulded to the leg, thigh, and pelvis. If pain is marked, the local application of hot fomentations or lead water and laudanum will often be of service. The patient should be carefully fed and given tonics, such as iron and quinine. Fixation of the joint should be maintained for some weeks, and after all pain, swelling, and tenderness have subsided the splint should be removed and the patient allowed to use the limb cautiously.

Acute Septic Synovitis and Arthritis of the Hip.—This condition may result from pyæmia, or from absorption from infected wounds, or by extension from an acute epiphysitis, or may occur as a complication of typhoid or scarlet fever, or measles. **Symptoms.**—The disease runs a rapid course, the limb soon becomes abducted, flexed, and everted, and the distended capsule of the joint is apt to rupture, allowing the pus to escape into the surrounding tissues; the head of the bone may also become dislocated from distention of the capsule. The patient at the same time complains of pain in the joint and has an elevated temperature. **Treatment.**—As soon as there is evidence of purulent effusion in the joint, it should be opened by incision, irrigated with sterilized water or bichloride solution, and thoroughly drained, and an extension apparatus or splint should be applied to fix the joint. The patient's constitutional condition should receive attention, stimulants, quinine, and iron being administered freely. It is remarkable that in many cases of acute septic arthritis of the hip recovery follows with a useful joint after incision and free drainage; in some cases, however, after the wounds have healed, more or less fixation of the joint results. If dislocation of the head of the bone has occurred, its reduction may often be accomplished by manipulation.

Tuberculous Arthritis of the Hip, Coxalgia, Hip-Joint Disease.—This is one of the most frequent joint-affections which come under the care of the surgeon, and is most common in children, but is occasionally seen in adults. The disease may be osteal or synovial in its origin. The tubercular deposit in the majority of cases takes place at the femoral epiphysis, or in the head of the femur under the articular cartilage, but it may also occur in the acetabulum or in the synovial membrane of the joint. Primary infection of the synovial membrane is probably much more frequent than is

generally supposed. In children the starting-point of the disease is almost without exception in the bone, at the epiphyseal line, or in the head of the femur; while in adults the synovial membrane is most frequently the seat of the primary infection. In many cases the exciting cause of the affection can be traced to traumatisms or exposure to cold, but in others the disease develops apparently without exciting cause.

Clinical History.—The symptoms which first attract attention are a slight limp, pain in the hip, or more commonly at the inner side of the knee, with a tendency soon to grow tired upon slight exertion, and starting-pains at night caused by muscular spasm. The child while asleep will suddenly cry out and become awakened, but soon drop off to sleep again. These symptoms the parent is apt to attribute to some fall or injury which the child has received, but upon careful questioning it is rarely found that a satisfactory connection between an injury and the development of the symptoms can be established. The symptoms may be gradually aggravated, so that the nature of the disease cannot be mistaken, or there may be a remission of some weeks or months, followed by the return of the same symptoms, the pain in the hip and knee, the limp, and the starting-pains at night being more marked than in the first instance.

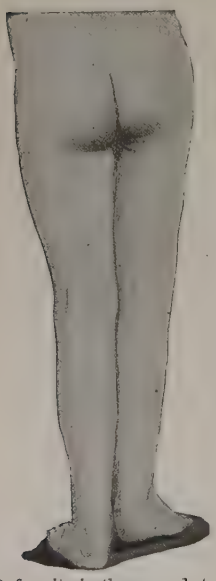
In the development of tuberculous disease of the hip three stages are recognized, each accompanied with distinctive symptoms. 1. The stage of deposition of bacilli, causing irritation and new growth. 2. The stage of fully developed arthritis, with the formation of embryonic tissue-masses and effusion into the joint. 3. The stage of caseation or abscess, with breaking down of the infected tissues, disorganization of the joint, and destruction of the periarticular tissues.

Symptoms.—First Stage.—There is slight lameness or stiffness in the articulation, the knee is slightly flexed, and the limb is abducted; stiffness may be more marked in the early part of the day than later, when considerable exercise has been taken. The patient is disinclined to play, and soon becomes tired. Rigidity of the muscles about the joint is observed, especially of the adductors. Pressure upon the trochanter or the sole of the foot causes pain in the hip-joint. Pain in this stage is not often marked, but may be complained of in the hip, or more frequently at the inner side of the knee, because of the relation of the obturator nerve to these articulations. Starting-pains at night may be present. The amount of pain depends largely upon the extent and rapidity of involvement of the bone; when the epiphysis and osseous tissue beneath the articular cartilage are involved, pain is apt to be a prominent symptom. The muscles may be slightly atrophied, and there may be some fulness over the joint in front of and behind the trochanter.

Second Stage.—This stage is characterized by the occurrence of marked deformity, caused by inflammation, with softening and partial destruction of the ligaments, and by changes in the bone-substance, and muscular contraction. The patient limps decidedly, the adductor muscles are rigid, the muscles of the thigh are atrophied, and effusion into the capsule may cause broadening of the hip-joint. The limb is abducted and everted, the buttock on the affected side is flattened, the gluteal muscles being wasted, and the

gluteo-femoral crease is obliterated. (Fig. 542.) The affected limb appears lengthened, but this is only an apparent lengthening, due to tilting of the pelvis from the efforts of the patient to throw the weight of the body in walking and standing upon the sound limb, and to preserve parallelism of the limbs. The accompanying diagram will illustrate these conditions. (Fig. 543.) Actual lengthening may occur in this stage of the disease from distention of the capsule with effusion. Pain is usually present, and may be referred to the hip or to the knee in the distribution

Fig. 542.



Deformity in the second stage of hip-disease.

Fig. 543.

Apparent elongation of left limb, due to abduction of the sound limb and tilting of the pelvis on the sound side, to allow the abducted limb to be brought into a line with the body. (Bryant.)

Abducted position of the diseased left limb when the pelvis is at right angles to the spine. (Bryant.)

of the obturator nerve. Motions of the joint are much restricted, full extension and complete adduction are not possible, and the deformity cannot be corrected even by the application of considerable force. During this stage the effusion may be absorbed, or may escape from the joint into the surrounding tissues, or abscess may occur.

Third Stage.—This is the stage of shortening and deformity. There are marked adduction of the limb and flexion of the thigh upon the pelvis, with prominence of the buttock upon the affected side. (Fig. 544.) The shortening results from adduction and from the change in the relation of the neck of the femur to the shaft, the obtuse angle becoming very nearly a right angle. The latter deformity occurs from muscular spasm and from bearing the weight upon the inflamed and softened bone. The deformed head and neck of the femur are also pushed upward and outward, so that the upper part of the trochanter may occupy a position above Nélaton's line. The flexion of the thigh upon the pelvis and the fixation of the joint are generally very marked. There is usually wasting of the muscles of the gluteal region and thigh. In this stage of the affection abscesses are very common, which open upon the skin in the region of the joint. Separation of the head of the bone from the neck may occur at the epiphyseal line, or there may be absorption of the head and neck of the bone. The acetabulum may be perforated

and pus may find its way through it to the surface, opening just below Poupart's ligament, upon the perineum or into the rectum or bladder. When an abscess opens spontaneously upon the surface, or becomes infected after opening by pyogenic organisms, pain, heat, tenderness, and profuse suppuration are added to the existing symptoms of the disease, and the patient presents the general symptoms of the hectic state. A certain number of cases of hip-disease pass through the various stages of the disease and recover without the formation of abscess, but usually present more or less deformity and impairment of function of the joint.

Fig. 544.

Deformity in the third stage of hip-disease. (Sayre.)

Dislocation of the head of the femur occasionally occurs during the course of the disease, particularly in those cases which have not been treated and in which there is great adduction, forcing the altered head of the bone against the upper rim of the acetabulum. In such cases very little absorption of the bone will allow the head of the bone to slip out upon the dorsum of the ilium.

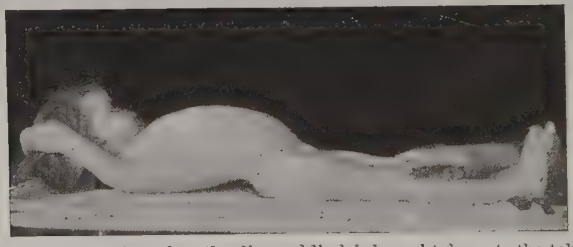
When recovery takes place in a case of advanced hip-disease there always result more or less deformity and loss of function in the joint; if free suppuration has occurred, the discharge from the sinuses may diminish, and after a time they may close, or they may persist for years after the disease is apparently cured. The amount of deformity and loss of function of the joint which result depend largely upon the stage of the disease at which the treatment was begun and the character of the treatment employed. Partial or complete *ankylosis*, which may be fibrous or bony, always takes place. Ankylosis in good position does not prevent the patient from having a fairly useful limb; the shortening can be overcome by the use of a thick sole or a raised shoe.

Complications.—Abscess.—This is a very common complication of hip-disease, occurring in about fifty per cent. of all cases. In cases in which appropriate treatment is employed early in the disease probably not more than twenty per cent. suffer from abscess, according to Gibney. Abscess usually results in sinuses, which may continue to discharge for some time and eventually heal. A very common seat of abscesses in hip-disease is upon the upper and anterior portion of the thigh, external to the femoral vessels, but they may occur at many other points, in the gluteal region, or on the inner aspect of the thigh, or, in cases in which the acetabulum is perforated, above Poupart's ligament, in the perineum, or open into the bladder or bowel. In cases of hip-disease in which there is long-standing suppuration,

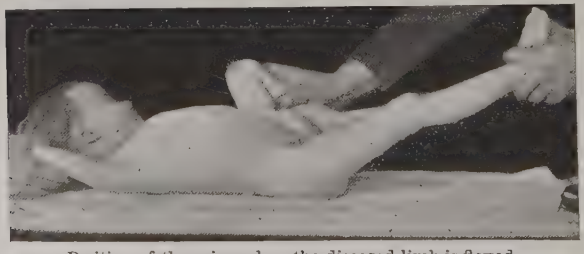
the patient may develop progressive emaciation and amyloid changes in the liver and kidneys, attended with albuminuria and anasarca, which are usually soon followed by death. **Tubercular meningitis** is a complication which not infrequently occurs during the course of hip-disease, and is almost always fatal. **Visceral tuberculosis** is also a not infrequent complication of hip-disease, and usually manifests itself after the joint-lesion is apparently cured.

Diagnosis.—It is sometimes difficult to make a diagnosis of hip-disease when the patient is seen in the very early stages of the affection, but if the surgeon will bear in mind the characteristic symptoms of the disease —limping, flattening of the buttock, loss of the ilio-femoral crease, atrophy of the limb, loss of motion or fixation in the movements of the joint, and starting-pains at night—he will seldom fail to recognize the true nature of the affection. In every case of suspected hip-disease a systematic examination should be made, the patient being stripped and examined standing, to observe the position of the limbs ; he should next be placed upon his back upon a flat surface, such as a table, and the length of the limbs should be compared and any change in their position noted. The condition of the joint as regards motion or fixation should next be carefully examined ; arching of the lumbar spine due to contraction of the psoas muscle when the leg and thigh are depressed is a most valuable diagnostic sign. When the thigh upon the sound side is flexed and then brought down so that the limb rests

FIG. 545.



Arching of the spine when the diseased limb is brought down to the table.



Position of the spine when the diseased limb is flexed.

upon the table, no change in the lumbar spine occurs, but if the same manipulation is practised upon the affected side a marked lumbar curve is developed, which disappears as soon as the knee is raised. (Fig. 545.) The surgeon should also examine for swelling and tenderness on pressure over the joint. Careful inquiry will elicit the history of limping and starting-pains.

Hip-disease may be confounded with caries of the spine, synovitis of the hip, periarthritis, perinephric or appendicial abscess, hysteria, infantile paralysis, malignant disease, and congenital dislocation.

Hip-disease may be differentiated from **caries** of the spine by the facts that in the latter the limp is different, the spine is rigidly fixed, and upon examination spinal deformity can usually be observed; the motions of abduction and adduction are restricted in hip-disease, while in spinal caries they are usually not impaired; extension may be limited from involvement of the psoas and iliacus muscles; in spinal caries palpation will often reveal an inflammatory mass or abscess in the region of the psoas muscle. **Acute synovitis** of the hip is a rare affection, and occurs after injury or exposure to cold. The deformity, which is noticed early, consists of fulness in the region of the joint, and the pain is referred to the joint; in hip-disease the symptoms develop more slowly, and do not yield so readily to treatment. **Periarthritis** is a phlegmonous inflammation of the cellular tissue over the hip, and is accompanied by fever, pain, and redness of the skin; an abscess soon forms, and upon opening this recovery takes place promptly. **Appendicial** and **perinephric abscess** may cause flexion of the thigh and limping from pressure of the collection upon the psoas muscle, but upon examination it will be found that adduction and abduction of the joint are not interfered with, and extension only is limited; abdominal or lumbar fulness, due to the presence of the abscess, can also be demonstrated. **Hysterical affections** of the hip-joint may simulate hip-disease, but in such cases many of the symptoms of the latter disease are wanting, and an examination of the patient under an anæsthetic will show that the motions of the joint are absolutely unrestricted, and other symptoms of hysteria can usually be demonstrated. **Infantile Paralysis.**—In this disease the history of the invasion is different from that in hip-disease; there is no pain, but paralysis with marked muscular atrophy, and there is also no fixation of the hip-joint.

Malignant disease of the hip is rare, and is more apt to be seen in adults, while hip-disease is more common in children. Sarcoma of the thigh in children is more apt to involve the shaft or the lower extremity of the femur, but may occur in the upper extremity of the bone. We have seen a case of sarcoma of the upper extremity of the femur in which at first the symptoms closely resembled hip-disease. **Congenital dislocation** cannot be confounded with hip-disease if the surgeon notes the waddling gait in the former affection, the absence of pain, and the fact that the deformity and peculiar gait were noticed as soon as the patient began to walk.

Prognosis.—This depends largely upon the surroundings of the patient and the treatment. In children who are well treated and well taken care of a large proportion of cases will recover, with more or less deformity or disability of the affected joint. In many cases of hip-disease, and especially the ill fed and poorly nourished cases which are admitted to children's hospitals, in spite of the most careful treatment, disorganization of the affected joint occurs, abscesses form, followed by profuse suppuration, amyloid changes in the liver and kidneys occur, or tubercular meningitis or visceral tuberculosis develops and causes a fatal termination. In well-to-do patients the prognosis is good; but the treatment may have to extend over a period

of months or years, and years after the case has apparently recovered a recurrence of the disease may take place.

Treatment.—The treatment is both local and constitutional, and the earlier it is instituted the better is the prospect of recovery with the least impairment of function in the joint. The local treatment consists in securing as nearly as possible absolute rest of the affected joint, at the same time correcting any deformity which exists, and using such appliances as will prevent subsequent deformity. The constitutional treatment of the case consists in the employment of all the means to improve the patient's general condition and nutrition which would be indicated in an enfeebled and tubercular state, such as fresh air, sea air, if possible, and nutritious diet, and at the same time tonics, as cod-liver oil and iodide of iron, may be used with good results.

The two methods of treatment which are most practised at the present time are **prolonged recumbency** with extension, and the use of **fixation** or **traction splints,** which allow the patient to walk about during the course of treatment. Each of these methods has its advantages, and the surgeon often has to be governed in his decision as to which method he will employ in any individual case by the duration of the disease and the age and social condition of the patient. Among the poorer classes the cost of fixation and traction splints and the lack of judicious care in their management prevents satisfactory results. Complete rest in bed in this class of patients is also very difficult to secure.

In many cases a combination of the two methods is followed by the best results. In the early stage of the disease recumbency and extension may be employed, and after a time the patient be allowed to go about with some form of fixation or traction splint.

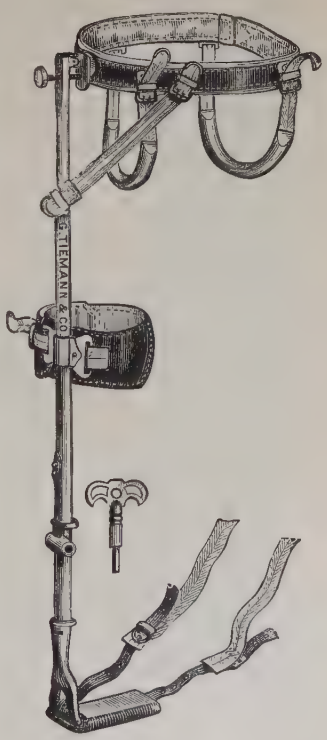
Prolonged Recumbency and Extension.—This method is especially applicable in the early stages of the disease and in young children, in whom a walking splint cannot be used with satisfaction. It is remarkable how well children stand confinement to bed for a long time if they are properly fed and have good hygienic surroundings. In this method of treatment an extension apparatus made of adhesive plaster or swans'-down plaster—either of which is preferable to rubber plaster, which is apt to irritate the skin—is applied to the leg and the lower part of the thigh, secured by transverse strips of plaster, and held in place by a gauze or muslin bandage. The patient is next placed upon a firm mattress, and a weight of from four to ten pounds is attached to the block at the bottom of the extension apparatus. Lateral support may be given to the limb by means of a long padded splint extending from the axilla to the sole of the foot, or by sandbags. Care should be taken to make extension in the line of deformity—that is, in the line of the flexed or abducted or adducted thigh—and as the deformity is corrected the position of the limb can be gradually changed to the normal one. The amount of weight necessary to produce extension varies in individual cases, and should be sufficient to overcome muscular spasm. If the starting-pain at night is not relieved, the weight should be increased; the tendency is to use too little weight; we often employ from six to twelve pounds. This treatment may be kept up for many months; if abscess does not occur no operative treatment is required. When the dis-

ease has been arrested the patient may have the hip-joint fixed by a moulded binders' board splint, with a high shoe upon the sound foot, and may be permitted to walk about on crutches for some time before he is allowed to use the limb in locomotion.

Fixation and Traction Splints.—In cases of hip-disease among well-to-do patients, when the appliances can be under the care of an intelligent parent or nurse, fixation and traction splints are often most satisfactory; by their use patients can go about and get change of air and scene, and the joint treatment can be carried on at the same time. The most inexpensive fixation apparatus for cases of hip-disease consists in a binders' board splint, moulded to the upper part of the leg, the thigh, and the pelvis, and secured in position by a bandage. In place of the binders' board splint a plaster of Paris bandage may be applied to the leg, the thigh, the pelvis, and the abdomen as high as the ribs. The patient should be fitted with a high shoe upon the sound foot, and should be allowed to walk about on crutches.

Another form of fixation splint known as Thomas's (Fig. 546) is very largely used, and is applied as shown in Fig. 547. The patient wears a high shoe upon the sound foot and walks by the aid of crutches. This splint may be made of sole-leather, with steel braces, and is convenient in application and equally satisfactory in its results. Various forms of traction splints may also be applied. In these extension is made to relieve muscular spasm, and at the same time, in many of them, fixation of the joint is secured. The splints of Taylor, Davis, Lovett, and Wyeth are constructed with this end in view; the extension is usually made by a ratchet with a movable foot-piece. (Fig. 548.) An extension apparatus of adhesive or swans'-down plaster is applied to the leg and the lower part of the thigh;

Fig. 548.



Traction splint.

Fig. 546.

Thomas's splint.

Fig. 547.

Thomas's splint applied.

buckles are fastened to the extension bands, which are attached to strips secured to the foot-piece; after being applied, extension is made by the ratchet.

During the course of treatment by any of these forms of splints abscess may develop, which will interfere with their use while the abscess is under treatment. The length of time treatment should be kept up, either by recumbency and extension or by splints, is often a matter of the greatest difficulty to decide, and it is a safe rule to continue it even after it seems not to be absolutely necessary, rather than to remove the fixation or traction apparatus before the course of the disease is arrested. No definite time can be given, months or even years of treatment being often required; and when the disease seems to be arrested, as indicated by the absence of characteristic symptoms and by the presence of firm ankylosis, the apparatus should be removed, and the patient should have some simple fixation apparatus applied for a few months; after which this may be removed, and the patient allowed to use the limb carefully in locomotion. If pain or tenderness returns, it is evident that the disease has not been cured, and the apparatus should be resumed.

Fig. 549.

Abscess in hip-disease.

Abscess in Hip-Disease.—This is one of the most troublesome complications that are liable to develop during the course of the disease, and may occur at any time except in the very early stage. The most common seat of abscess in connection with hip-disease is upon the anterior aspect of the joint (Fig. 549), the tuberculous débris finding its way to the surface between the tensor vaginæ femoris and sartorius muscles; it may work its way posteriorly and reach the surface in the gluteal fold, or the pus may open into the bursa beneath the psoas muscle over the front of the femur and find its way into the pelvis under Poupart's ligament. It may also perforate the anterior portion of the capsule and pass down the inner part of the thigh beneath the adductor muscles. Abscess which starts in the acetabulum is apt to perforate the bone and form a collection under the iliacus muscle; pelvic abscess may ascend under the muscles and point under Poupart's ligament, may open into the rectum, or may enter the bursa under the tendon of the psoas muscle and make its way to the inner aspect of the thigh.

Treatment.—Abscesses may form slowly or rapidly, and sometimes assume such a size that they interfere with the use of apparatus. As soon as it is evident that pus is present, this should be removed, by aspiration or incision. Gibney holds that the most satisfactory results follow repeated aspiration or small incisions; we have, however, seen the best results from small incisions followed by injection of the cavity with iodoform emulsion and closure of the wound by a compress of gauze, this procedure being repeated as often as the cavity refills. It often happens

that in spite of any method of treatment the sinus remains open and continues to discharge for some time; this will persist as long as any débris is cast off from the diseased bone and cartilages. When the discharge becomes chronic, opening up of the sinuses and curetting them will sometimes be followed by their rapid closure.

Operative Treatment of Hip-Disease.—In cases of hip-disease some surgeons recommend early excision of the diseased head and neck of the femur, while others postpone operation upon the bone as long as possible, merely opening and draining abscesses if they form, and depending upon ultimate ankylosis of the joint, which if it be in bad position can be corrected by an osteotomy at a later period. There are, however, many cases of hip-disease which do badly in spite of the most careful treatment; abscesses form, infection occurs, the patients suffer from hectic, and exhaustion soon supervenes by reason of the profuse suppuration. In such cases operative treatment must be considered, and a free exposure of the joint and excision of the diseased bone in such cases are often followed by the most satisfactory results. The special method employed in excision of the hip depends upon the time at which the case is seen. Where the bulk of the suppuration is in the gluteal region or the posterior aspect of the thigh, as often happens in long-standing cases, we prefer the posterior incision; while where abscess forms anteriorly, as is frequently seen in early cases, we prefer the anterior incision. The anterior incision is also to be preferred in cases of early excision, before abscess has occurred or much destruction of the joint-tissues has taken place. The methods of excising the hip-joint, as well as the correction of the deformity following hip-disease, are considered in the chapter upon Excisions.

After excision of the hip-joint there is often a remarkable improvement both in the constitutional and in the local condition of the patient; the wound and sinus often heal promptly, and the patient may soon regain fair use of the limb. In other cases sinuses may continue to discharge for some time, new abscesses may form and require opening, and it may be necessary to reopen the wound and remove more diseased bone and infected soft tissues. The most favorable result following excision of the hip is to have a false joint form, allowing more or less motion; shortening, to a certain extent, will always be present, and can be overcome by the wearing of a high shoe on the affected limb. We have seen so many good functional results follow excision of the hip that we are disposed to recommend the operation in all cases in which the disease runs a rapid course and suppuration is free, in which hectic is well developed, and where the limb is distorted so that it would be useless if ankylosis occurred subsequently.

Amputation in Hip-Disease.—In cases of advanced hip-disease in which amyloid changes have occurred in the liver and kidneys, and suppuration is very profuse, or in which, in spite of excision of the joint, suppuration, hectic, and exhaustion continue, amputation of the limb may be required as a life-saving measure, and even in such hopeless cases, with the modern methods of controlling hemorrhage during the operation, a fair number of recoveries take place. Amputation, therefore, should be considered in these cases.

DISEASES OF THE KNEE-JOINT.

The knee-joint may be the seat of simple synovitis, acute suppurative synovitis or arthritis, and tubercular synovitis or arthritis; there are also observed not infrequently cases of chronic synovitis of the knee-joint, with marked effusion, which may be tubercular or may be independent of the presence of the bacillus tuberculosis.

Simple Synovitis.—This may result from traumatism, from exposure to heat or cold, or from over-exertion. **Symptoms.**—In this disease there are pain and swelling of the joint, with loss of function, the swelling being due to effusion in the joint and œdema of the extra-articular structures. The temperature is usually elevated, and the pulse is increased in frequency. The presence of effusion in the joint can usually be proved by the floating of the patella; when this is pressed upon it can be made to touch the condyles of the femur; when the pressure is relieved it springs back into place. The knee is flexed if the effusion is considerable, this position being assumed to relieve tension and pain. The only condition with which this affection can be confounded is hemorrhage into the joint, which occurs earlier than synovial effusion and is much more consistent to the touch. **Treatment.**—The patient being put at rest in bed, the knee-joint should be fixed by the application of a posterior splint, and the joint covered with lint saturated with lead water and laudanum, or an ice-bag applied. Under this treatment, usually in a few days the active symptoms disappear. The fixation should be continued until the effusion has disappeared, and when the patient begins to move about the joint should be supported by a flannel bandage. Massage also is useful in hastening the absorption of the effusion and restoring function.

Acute Suppurative Synovitis or Arthritis.—This affection may result from penetrating wounds of the knee-joint or infection of the joint by the localization of pyogenic organisms from the blood-vessels, as seen in cases of pyæmia. **Symptoms.**—The joint becomes red, swollen, and painful, there is loss of function, and the position of the articular surfaces is changed so as to afford the patient relief from the distention; the patient at the same time exhibits the symptoms of constitutional infection, elevation of temperature, rapid pulse, rigors, and sweating. **Treatment.**—The treatment which affords the best results is early and free incision of the joint, with irrigation, and the introduction of gauze or rubber drainage; the joint should be covered with a copious gauze dressing, and put at rest by the application of a splint or a plaster of Paris dressing. If incisions are made and free drainage secured before the articular cartilages have been destroyed, a good result as regards function of the joint follows in many cases.

Chronic Synovitis.—This affection is sometimes seen in the knee-joint independently of the presence of tubercle, and may consist either in great thickening of the structures of the joint or in a large effusion into it; the latter condition is known as *hydrops articuli*, and through stretching of the capsule and the ligaments the joint is rendered weak and insecure. **Treatment.**—In many cases of chronic synovitis of the knee the use of blisters or of counter-irritation by other means, or the application of an ointment com-

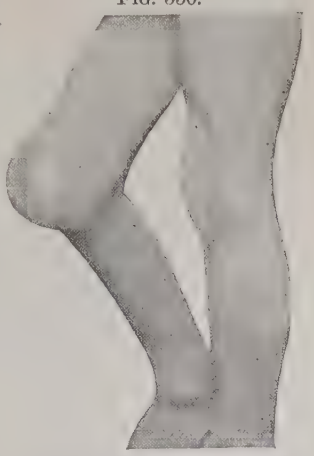
posed of equal parts of ungt. iodi, ungt. belladonnæ, and ungt. hydrargyri, combined with fixation of the joint by splints or plaster of Paris, will ultimately effect a cure.

In other cases, in which the effusion is not large and the swelling depends upon the hypertrophy of the synovial fringes, the results of counter-irritation and fixation are not so satisfactory; here pressure, applied by a bandage or by strapping, may promote the absorption of the inflammatory material. When in spite of all these forms of treatment the condition is not improved, it is justifiable to aspirate the joint and irrigate it with a five per cent. carbolic solution, or to open it, the strictest aseptic details being observed, and trim away the hypertrophied synovial fringes. The wound should afterwards be closed, and the joint immobilized by a plaster of Paris dressing. After the wound is solidly healed, massage and passive motion should be employed to bring about restoration of function.

Tuberculous Arthritis of the Knee.—This disease is most frequently met with in childhood, but is often seen in young adults, and in point of frequency is next to hip-disease. The disease is usually osteal in origin, the articular surface of the femur being much more frequently involved than the tibia. It is extremely rare for the disease to originate in the patella. In adults the synovial membrane of the joint may first be involved, and the bone, ligaments, and periarticular structures involved secondarily. The changes which occur in the tissues are similar to those which have been already described as typical of tubercular arthritis.

Symptoms.—The patient complains of pain in using the limb, favors it in walking, and walks with a limp, bearing the weight upon the toes and the ball of the foot. Upon examination there may be observed some heat in the joint, and reflex muscular spasm may be noticed upon motions of the joint; stiffness may be present. Later there is slight flexion, with change in the shape of the joint, which becomes globular, the change being more marked by reason of the atrophy of the muscles above and below the joint. As the disease advances the limb becomes more flexed, and the tibia is drawn backward, producing a subluxation. (Fig. 550.) The synovial membrane and the cartilages may be broken down; the tubercular masses may undergo caseation and form abscesses, which perforate the capsule and escape into the periarticular structures, and finally open upon the skin in the region of the joint. In other cases no abscesses form, but disorganization of the joint, with deformity, occurs, which may be followed by ankylosis.

Fig. 550.



Tuberculous arthritis of the knee.

Diagnosis.—Tuberculous arthritis of the knee-joint may be confounded with **acute arthritis** of the knee; the latter comes on soon after exposure to cold or after an injury, and runs a rapid course. **Cellulitis** of this region develops rapidly, and is usually phlegmonous. **Rheumatic**

arthritis is generally an acute affection, and is accompanied with marked constitutional symptoms. **Chronic bursitis** of the knee, which is often tubercular in origin, is sometimes difficult to distinguish from tuberculous arthritis, especially if the bursa involved communicates with the knee-joint, but may be distinguished from the latter by observing that the bursa is distended, that the effusion into the knee-joint is not marked, and that the joint motions are not much affected. **Neuroses** of the knee-joint are unaccompanied by physical signs other than flexion. **Sarcoma** in this location usually involves the articular end either of the tibia or of the femur, and the enlargement extends some distance above or below the joint. The pain in sarcoma is of a boring character, and pulsation may often be felt, which is a most valuable diagnostic sign. In cases of sarcoma the joint may be involved secondarily.

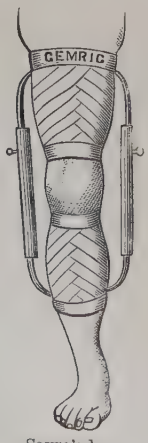
Treatment.—In the treatment of tuberculous arthritis of the knee the first indication is to put the joint at absolute rest. This may be accomplished by the use of the plaster of Paris bandage, or by some form of splint which furnishes at the same time both fixation and traction. The patient should use crutches, and wear a high shoe on the sound foot, so that no weight can be borne on the affected leg, thus securing complete physiological rest of the diseased joint. The patient's constitutional condition should also receive attention; the diet should be nutritious, and such remedies as tonics, cod-liver oil, and iron should be administered.

When the plaster of Paris bandage is employed it should extend from the toes or the lower part of the leg to the upper part of the thigh, or a movable splint of sole-leather, made to fit the leg accurately by moulding leather upon a cast made from a neatly fitting plaster bandage, may be used, which has the advantage that it can be removed to bathe the limb. Thomas's splint (Fig. 551), or that of Sayre (Fig. 552) or of Shaffer, may be employed with advantage; the latter are so constructed that they make traction at the same time that fixation of the joint is produced. The course of treatment may extend over months or years. In many cases abscesses form, which should be opened and drained, and if ankylosis occurs with the limb in good position the result may be counted as favorable as that obtained by operative means.

Fig. 551.

Thomas's knee-splint.

Fig. 552.



Sayre's knee-splint.

Cases often come into the hands of the surgeon in which the joint is so much flexed that a splint cannot be satisfactorily employed, and if the limb should become ankylosed it would be of little use to the patient. In such cases the use of extension by weight and pulley will often correct the deformity; if not, the patient should be etherized, and with a little force, and possibly by the division of the hamstring tendons, the limb can be brought into a nearly straight position, after which it can be put up in plaster of Paris, or a splint may be applied.

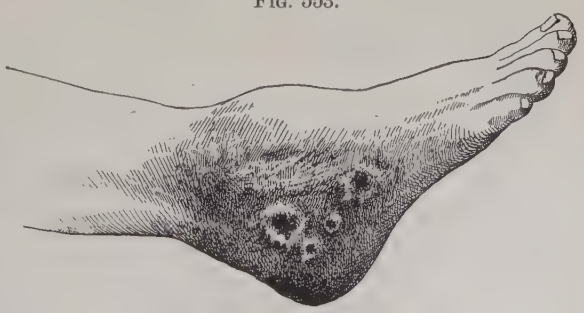
By the use of some of these various forms of fixation apparatus recovery may occur with more or less loss of function in the joint. The amount of motion remaining depends largely upon the extent of destruction of the articular cartilages. In cases where the disorganization of the joint is extensive and the patient suffers from hectic and is losing ground, the question of operative treatment must be considered. Excision, arthrectomy or erasion, or amputation may be performed. **Arthrectomy** or erasion is to be preferred to **excision** in young children, as the latter operation is apt to damage the epiphyseal cartilages and interfere with the subsequent growth of the limb. Amputation is reserved in disease of the knee-joint for cases in which there is extensive disorganization of the joint with involvement of the contiguous bones and soft parts. The special operations upon the knee-joint are considered under Excisions.

AFFECTIONS OF THE ANKLE-JOINT.

Simple Acute Synovitis.—This condition usually arises from traumatism, and is characterized by the symptoms of acute synovitis—limitation of motion, pain, and swelling; the swelling may be most marked in front of the joint on either side of the extensor tendons, or behind the joint on either side of the tendo Achillis. **Treatment.**—This consists in putting the joint at rest by the application of a splint and the use of such lotions as lead water and laudanum or muriate of ammonium and laudanum. After a few days, when the pain has diminished and the swelling has subsided, the joint should be fixed by the application of a plaster of Paris dressing or a silicate of sodium splint. Care should be taken not to keep the joint immobilized for too long a time, and after wearing either of these dressings for a few weeks they should be removed, and the patient encouraged to use the joint. Massage in the latter stages of this affection is often most useful in bringing about restoration of function.

Tuberculous Arthritis of the Ankle-Joint.—Tuberculous disease of the ankle-joint may be either synovial or osteal in its origin. The disease is more apt to develop in the astragalus than in the articular ends of the bones of the leg, or it may be secondary to disease of the other tarsal bones or of the malleoli.

FIG. 553.



Tuberculous arthritis of the ankle.

Symptoms.—In this affection there is stiffness of the ankle, and more or less swelling is usually observed about the anterior surface of the ankle or behind the joint on each side of the tendo Achillis. If there is much intra-articular effusion, swelling may be marked. Pain, characteristic of ostitis, is also present, and is most marked when attempts are made to move the joint. As the disease advances, the foot is held in the extended position and

the contour of the joint is changed, so that a globular swelling is present at the ankle. Abscesses may form, which, when opened, are likely to leave discharging sinuses. (Fig. 553.) The prognosis is always grave in tuberculous disease of the ankle-joint, and depends upon the age and constitutional condition of the patient.

Treatment.—As in other tuberculous joints, fixation is one of the most important indications in treatment. The joint should be immobilized by a plaster of Paris dressing, or by moulded leather or binders' board splints; care should be taken that the foot is kept at a right angle to the leg, so that if ankylosis occurs it will be in good position. The bandage should be renewed at intervals as the swelling subsides, and a fresh one applied. The patient should also use crutches, to keep the weight off the diseased joint. The injection of iodoform emulsion or chloride of zinc, combined with fixation of the joint, may often be used with good results. When the disease is well advanced and abscesses have formed, these should be opened and drained; if the swelling continues and the discharge from the sinuses is profuse, and the patient's constitutional condition shows that he is suffering from the profuse discharge, some form of operative treatment, such as erasion, excision, or amputation, should be adopted.

Erasion may be first employed, or excision may be preferred, care being taken that all diseased structures, both bony and of the soft parts, are freely removed. Extensive removal of bone is often demanded. The tarsal bones are sometimes extensively affected and require removal, as well as the lower ends of the tibia and fibula. Excision of the ankle in children for tuberculous disease is followed by good results, but in adults our experience has been that this operation is not so satisfactory and that amputation is often subsequently required.

AFFECTIONS OF THE TARSAL JOINTS.

These joints may present simple acute synovitis following traumatism, as well as tuberculous synovitis or arthritis. **Acute synovitis** of the tarsal articulations usually follows an injury, and presents the symptoms of acute synovitis, pain, swelling, and loss of function. The *treatment* of this condition consists in the use of evaporating lotions and fixation of the inflamed articulation by a splint. Recovery generally takes place promptly after the joint is put at rest.

Tuberculous arthritis of the tarsal articulations is characterized by swelling, which comes on slowly and gradually causes marked change in the shape of the foot; pain may not be a prominent symptom, except in the later stages of the affection; there is loss of function, and the patient is disinclined to use the part. The disease usually runs a slow course, and often caseation takes place, and tuberculous abscesses form, which open upon the surface of the skin and leave discharging sinuses.

Treatment.—In the early stage of this affection fixation of the articulation should be obtained by the use of moulded leather or binders' board splints, or, better, by a plaster of Paris bandage applied from the toes to a point above the ankle-joint. The injection of iodoform emulsion in conjunction with immobilization may also be employed with good results. After

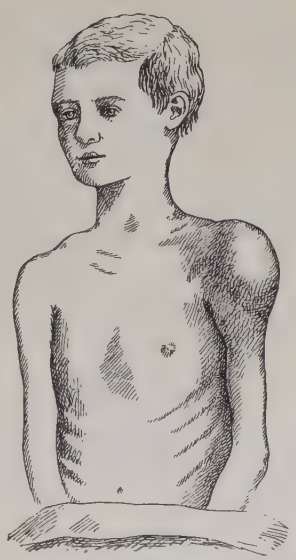
abscesses have formed, if the swelling persists and the discharge continues, the diseased structures should be exposed by incision, and the softened and carious bones, as well as the diseased soft parts, should be removed by a gouge or curette. It is often necessary to make a very extensive removal of the tarsal bones in these cases, and a thorough operation is much more likely to be followed by good results than an incomplete one. After removing all the diseased structures the wound should be thoroughly irrigated with an antiseptic solution and packed with iodoform gauze. The foot should be kept in good position with moulded splints of binders' board or with a plaster of Paris dressing, fenestræ being cut through which the wound can be dressed. After free removal of the diseased structures the foot is often very much shortened, but if the parts heal satisfactorily a very useful member results.

AFFECTIONS OF THE SHOULDER-JOINT.

This articulation may be the seat of acute synovitis or of tuberculous synovitis or arthritis. The symptoms of *acute synovitis* are similar to those seen in other joints, and the treatment is the same.

Tuberculous Synovitis or Arthritis of the Shoulder-Joint.—This is not a common affection, being met with infrequently as compared with tubercular disease of the hip-, knee-, or elbow-joint. It may be synovial or osteal in origin.

FIG. 554.



Tuberculous arthritis of the shoulder.

Symptoms.—In cases of synovial origin, swelling, effusion, and limitation of motion are observed early in the disease; in those of osteal origin, the swelling and effusion are not marked, and thickening of the bone, with considerable pain and atrophy of the muscles, is observed. The deformity in this affection is well shown in Fig. 554. Abscesses may form, which are apt to point either in front of or behind the deltoid muscle.

Treatment.—This consists in fixation of the joint by the application of a moulded splint to the shoulder and arm, which is bound to the side of the chest. Injections of iodoform emulsion combined with fixation are most successfully employed in this joint, and often result in recovery with more or less restoration of the motions of the joint. Excision of this joint is much less frequently required than of the knee-, hip-, or elbow-joint. If, however, abscesses form, and the head of the bone or the articular surface of the scapula is softened or carious, excision may be demanded. Very excellent functional results follow excision of the shoulder for tuberculous disease.

Dry Tuberculous Arthritis of the Shoulder-Joint (Caries Sicca).—This affection attacks the shoulder-joint more frequently than any other joint

in the body, and is most common in young adults. In this disease there is often very extensive destruction of the head of the bone, swelling of the soft parts is not marked, as in ordinary cases of tuberculous arthritis, and the occurrence of abscess is rare. The most prominent symptoms are persistent and severe pain, muscular wasting, and loss of function of the joint. It is not likely to be confounded with monarticular rheumatism, which is generally observed in subjects more advanced in age. **Treatment.**—In this variety of arthritis counter-irritation and early fixation of the joint are often followed by good results. If these means are carefully employed operative treatment is seldom required.

DISEASES OF THE ELBOW-JOINT.

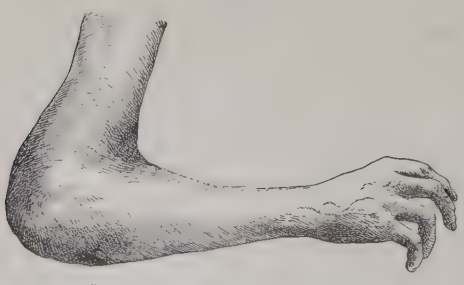
This joint may be the seat of acute synovitis or of tuberculous synovitis or arthritis.

Acute Synovitis.—This affection of the elbow usually follows traumatisms or exposure to cold, and presents the following symptoms: stiffness, and pain upon motion, soon followed by more or less effusion, most marked posteriorly on each side of the olecranon; the limb is held in a semi-flexed and semi-pronated position. **Treatment.**—This consists in fixation by the use of a splint and in the application of evaporating lotions. The acute symptoms usually subside rapidly under this treatment, and as soon as the swelling and tenderness have disappeared, passive motion and massage should be practised to restore the function of the joint.

Tuberculous Arthritis.—The elbow is much more frequently affected with tuberculous disease than any other of the joints of the upper extremity. The disease is often seen in childhood, and is usually of synovial origin, but may be osteal, the seat then being commonly in the lower articular extremity or in the lower epiphysis of the humerus.

Symptoms.—The disease usually develops slowly; there are stiffness and flexion of the joint; pain may not be a prominent symptom, except when the bone is the starting-point, when it can be developed by pressure upon the lower end of the humerus. Effusion may occur, and is most marked at the posterior surface of the joint on each side of the olecranon. As the disease progresses the swelling becomes greater and the muscles atrophy, causing the joint to present a spindle-shaped appearance; the flexion increases, and the forearm is held in a position of pronation or semi-pronation. (Fig. 555.) If caseation occurs, abscesses are apt to point upon the posterior and lateral aspects of the joint.

Fig. 555.



Tuberculous arthritis of the elbow.

Treatment.—As soon as the disease is recognized the joint should be fixed by the application of a splint or a plaster of Paris bandage. The flexed position, at an angle of ninety degrees or less, is that which is most comfortable to the patient, and also that in which the arm will be most

useful to the patient if ankylosis occurs. Injections of iodoform emulsion and fixation may be followed by the arrest of the disease and recovery with a useful arm with a moderate amount of restriction in the motions. If abscesses form, they should be opened and drained, and fixation should be maintained. After the sinuses have healed, ankylosis may take place, and the arm may be useful if it has been held at a right angle. If the disease is progressive or there are free discharge and other evidences that disorganization of the joint has occurred, erasion or excision should be performed. In adults early operations should be practised; in children it is better to wait until disorganization of the joint has taken place. We have seen many very useful arms follow the excision of tuberculous elbow-joints. In excising such joints the diseased structures should be very freely removed, but less extensive operations should be practised in children, to avoid injury of the epiphyses.

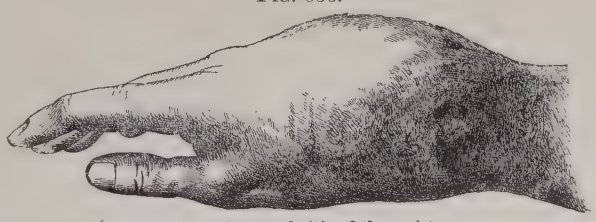
DISEASES OF THE WRIST-JOINT.

This joint may be the seat of acute synovitis or of tuberculous synovitis or arthritis. *Acute synovitis*, which arises sometimes from injury, but more commonly from general septic infection, does not differ in its symptoms or its treatment from the same affection in other joints.

Tuberculous Synovitis or Arthritis of the Wrist.—This affection may be synovial or osteal in its origin, and rarely originates in the articular surface of the radius, being most frequently consequent on synovitis of the carpal articulations or ostitis of the bones of the carpus. It may occur in children or in adults, but in our experience it is more common in adults.

Symptoms.—The joint becomes stiff, and swelling occurs upon the dorsal surface of the wrist on each side of the extensor tendons. As the swelling increases the muscles become wasted, so that the region of the wrist presents a spindle-shaped appearance which is very characteristic. (Fig. 556.) Pain may not be a marked symptom unless the joint is moved, but when the bones are extensively involved it is often severe.

Fig. 556.



Tuberculous arthritis of the wrist.

Treatment. — This consists in putting the joint at rest as soon as the disease is recognized. Injections of iodoform emulsion may be employed with good results. If abscesses form, they should be opened and drained, and fixation should be continued. Even in cases of extensive disorganization of the joint, when excision would seem to be indicated, free drainage seems to us to offer the patient a better chance of recovery than excision. We have rarely seen a good result following excision of the wrist in advanced cases of tubercular disease, the majority of the cases in which this operation had been done requiring amputation later. If, however, the operation is

not postponed until extensive disorganization of the joint has occurred, more favorable results may be obtained. In cases in which profuse discharge and pain are wearing the patient out, we consider amputation a better operation than excision.

Metacarpo-phalangeal or *interphalangeal* joints may be the seats of tuberculous arthritis, and the treatment is similar to that employed in the larger joints.

Tuberculosis of the Sterno-Clavicular and Acromio-Clavicular Articulations.—These articulations are occasionally the seats of tuberculous disease, the synovial membranes, cartilages, or bone being involved. The pathological conditions are similar to those in tuberculosis of other articulations. The **treatment** is similar to that appropriate for other tuberculous joints—fixation and drainage of abscesses and the removal of the diseased structures by means of the gouge or curette. In the removal of carious bone, care should be taken not to injure the costo-clavicular or coraco-clavicular ligaments, which prevent displacement of the clavicle.

Sacro-Iliac Disease.—Disease of the sacro-iliac articulation is a comparatively rare affection, and is usually seen in young adults, rarely in children. It may arise apparently without exciting cause, or may follow contusions or strains of the pelvis; here a traumatism, as in other articulations, may be the localizing cause of tubercular inflammation. The pathological changes are effusion and exudation, with the formation of granulation-tissue, destruction of the cartilages and bone, and breaking down of tuberculous masses, giving rise to tuberculous abscesses. The contents of such abscesses may point externally in the region of the sacro-iliac joint, or, passing internally, may enter the pelvis and be discharged into the rectum, or may find their way through the sacro-ischiatic foramen into the buttock, or may descend between the obturator and levator ani fasciæ, reach the ischio-rectal fossa, and point at the side of the anus.

Sacro-iliac disease is always a serious affection, and is especially likely to be followed by an unfavorable termination if abscess and extensive destruction of bone occur. In cases in which caseation of the tuberculous products does not occur, the prognosis is more favorable.

Symptoms.—In the early stage of the disease the patient complains of stiffness and occasional pain in the sacro-iliac joint, and of discomfort in standing or walking. Pain may also be noticed in coughing or sneezing, and in defecation. As the disease advances, the body is inclined to the sound side, and the weight of the body is supported as far as possible upon the sound limb, so that there is apparent lengthening of the limb upon the affected side. Swelling may be marked, particularly if external abscess is present. This disease may be confounded with hip-disease, from which it is to be distinguished by the facts that there is fulness over the sacro-iliac joint, that there is no fixation of the hip-joint, and that pain is referred to the region of the sacrum. In sacro-iliac disease, pressing the ilia together causes marked pain. Gonorrhœal or septic synovitis or arthritis may also affect this joint, but in such cases the disease can usually be traced to the original infecting cause, and it runs a much shorter course.

Treatment.—This consists in putting the diseased articulation at abso-

lute rest, and supporting the patient by a generous diet and the use of tonics and stimulants. Rest of the joint is secured by confinement to bed, with a firm binder or strips of plaster applied to the pelvis, or the plaster of Paris bandage may be used to secure fixation, being applied so that it includes the pelvis and fixes the hip-joint at the same time. In the early stage of the disease the actual cautery applied to the affected region often relieves the pain and seems to check or limit the progress of the tuberculous inflammation. The injection of iodoform emulsion, even after caseation has occurred, is often of service. When abscesses have formed, they should be opened with aseptic precautions and drained; intrapelvic drainage by tubes may be required in some cases, and is often of value. When carious bone or sequestra are present, their removal should be accomplished by the use of the gouge or the curette. Extensive removal of bone may be required in some cases, and is often followed by good results.

CHAPTER XXII.

OPERATIONS UPON THE JOINTS AND BONES.

EXCISIONS OR RESECTIONS.

Excision of a joint implies the partial or complete removal of the articular surfaces of the bones making up the articulation. The term *resection* is also used as synonymous with excision, but is employed by some authorities to indicate the removal of a portion or the whole of the shaft of one of the long bones.

The operation of excision or resection is employed in injuries of bones and joints, such as compound fractures and dislocations, or in the case of unreduced dislocations which render the limb useless or painful. This procedure is also very frequently resorted to in diseases of the joints in which inflammation resulting from pyogenic or specific infection has so seriously disorganized the joint or produced so much deformity that great impairment of function results. The operation is also required for the removal of growths, either benign or malignant, which have their origin in the bones.

Excision is now widely employed in the treatment of destructive diseases of the joints which were formerly treated by amputation, and the former operation should, if possible, always be preferred to the latter. It is, however, not to be recommended in very young patients, as in such cases the injury of the epiphysis is apt to interfere with the subsequent growth of the bone.

Excision finds its widest application and its greatest utility in the treatment of tuberculous affections of the joints of the extremities; in these cases by its employment it is often possible to remove the infected tissues and at the same time to preserve a useful limb, and in certain cases to have more or less complete restoration of function in the articulation. The employment of aseptic methods has also of recent years very much increased the field of excision and resection, for by the use of these means it is common to have prompt union in the wounds, whereas before their introduction these operations were often contra-indicated on account of the profuse and prolonged suppuration which followed.

The result desired in excision or resection, in addition to the removal of diseased tissues, varies somewhat with the part involved. In excision of the hip, ankle, shoulder, elbow, and wrist we aim to secure fibrous and not bony union of the bone surfaces, so that a movable joint results, while at the knee-joint bony ankylosis gives the best functional result. When the former result is desired, care should be taken not to divide muscles or tendons transversely, and as far as possible not to interfere with their attachments; where bony ankylosis is desired, the division of muscles and tendons

is not a serious consideration. Injury of important arteries, veins, and nerves should be avoided. The periosteum should be preserved as far as possible, to gain the benefit of its osteogenetic function in the subsequent repair of the wound, and also by its preservation the attachment of muscles may be retained. A form of *subperiosteal excision* or *resection* is employed with this object in view, which may be used in operations when undertaken for disease in which the periosteum is much thickened and can be readily separated from the bone, but when practised in cases of injury the preservation of the periosteum is often impossible. Resection of a portion of a bone may be required for the removal of a benign growth, and in such a case as much of the bone as possible should be left, so as not to interfere seriously with its function. A partial resection for the removal of a malignant growth of the bone is not followed by good results, and amputation where it is possible should be preferred. In cases where so large a portion of the shaft of a bone has been resected that great shortening and subsequent loss of function would result, bone-grafting may be employed, filling the defect with decalcified bone chips, or suturing a portion of a bone of a freshly killed animal between the resected ends of the bone. When a portion of one of two parallel bones is removed, to prevent deformity and loss of function bone-grafting or the removal of a similar section from the parallel bone may be practised.

In excision of joints where ankylosis is desired, primary fixation of the excised surfaces of the bone may be obtained by the use of sutures of chromicized catgut or silver wire, or by the use of steel nails, screws, or ivory pins; in resection of a portion of the shaft of a long bone, primary fixation of the ends of the bone should always be practised by the employment of some of these means. In the after-treatment of excisions and resections, as soon as the wound has been dressed additional fixation of the parts should be secured by the use of splints or of a plaster of Paris dressing. In cases in which bony ankylosis is desired, these should be retained for some weeks, but where a movable joint is sought for, as soon as the wound is firmly healed the splint should be removed and movement encouraged between the ends of the bones. Prolonged fixation in these cases naturally tends to limit the motion at the seat of operation.

Fig. 557.

Lion-jawed forceps.

Osteoplastic resection, which consists in turning up a flap of bone with the soft parts and the periosteum attached, is sometimes employed to expose the deeper portions of the bone, the nerves, or the brain. When the operative procedure has been accomplished, the flap is replaced and sutured in position. This form of resection is often practised in operations upon the cranial nerves, to expose the brain for the removal of tumors, or for exploration, and in the jaw for the exposure of growths situated in the naso-pharynx.

Instruments required for Excision.—In performing excisions or resections of bones or joints the following instruments will be found neces-

sary : a stout scalpel with a heavy blade, a probe-pointed knife, an excision saw with a reversible blade, a narrow-bladed saw or a chain saw, strong lion-jawed forceps (Fig. 557), retractors, elevators, heavy bone-cutting pliers, knife-bladed forceps, and a periosteotome.

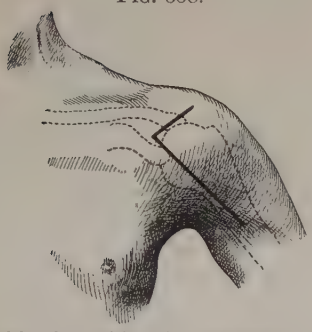
EXCISION OF SPECIAL JOINTS.

Excision of the Shoulder-Joint.—This operation generally consists in excision of the head of the humerus, but occasionally both this portion of the bone and the articular surface of the scapula are removed. It is required in cases of compound comminuted fractures of the head of the humerus and of severe gunshot injuries of this joint, for the relief of deformity following unreduced dislocations or badly united fractures of the neck of the humerus, and occasionally in cases of arthritis. In many cases of compound fracture or gunshot injury of the head of the humerus a formal excision is not required ; if great care is taken to keep the wound aseptic, the simple removal of detached fragments of bone, with careful drainage of the wound, will be followed by results as good as those from a formal operation.

Operation.—In excising the shoulder-joint the arm should be adducted and rotated inward, and a straight incision, three inches in length, should be made, extending from the beak of the coracoid process down the arm in the line of the bicipital groove (Fig. 558) ; if more room is required, this incision should be supplemented by a short transverse one from the upper edge of the first incision to the acromion process. As the incision is deepened the fibres of the deltoid muscle are divided in this line, and the capsule of the joint is exposed and divided along the outer edge of the tendon of the long head of the biceps muscle. This tendon should be held to one side and the capsule of the joint freely opened ; the periosteum over the upper portion of the neck of the humerus should then be divided and separated as far as possible from the bone. The muscles inserted into the tuberosities of the humerus are next divided with a probe-pointed knife and freed with an elevator. The head of the bone may then be forced out of its articular cavity by forcibly adducting and pressing the arm upward, and can be removed by sawing through its surgical neck with a narrow-bladed saw. (Fig. 559.) In some cases, however, it is difficult to disarticulate the head of the bone, and under such circumstances the neck of the bone may be divided, while the head remains *in situ*, by bone forceps, or by sawing across its surgical neck with a narrow metacarpal saw, or by passing a chain saw under the bone and sawing it from within outward. After the neck of the bone has been divided, the head is grasped with bone forceps and is twisted loose from its attachments in the articular cavity. After the removal of the head of the bone, the sawn surface of the humerus should be rounded off with gouge forceps, so that no sharp edges shall be present ; the articular surface of the scapula should next be carefully examined, and if this be found diseased, the diseased portion should be removed with a gouge or with gouge forceps. The wound should next be thoroughly irrigated, bleeding being arrested by torsion or by the application of ligatures, and the bone replaced ; a drainage-tube is then introduced to the depth of

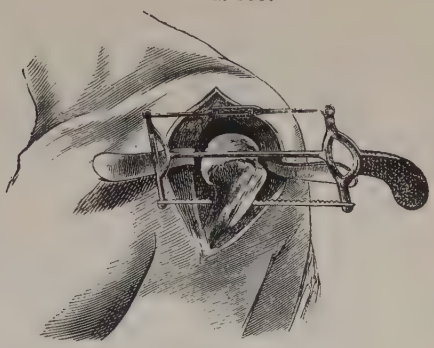
the wound, which should be closed by sutures. The dressing consists in the application of a gauze dressing, with a pad of gauze in the axilla, and the arm should be fastened to the side in the Velpeau position. A very satis-

Fig. 558.



Incision for excision of the shoulder-joint.

Fig. 559.



Excision of the shoulder-joint. (Agnew.)

factory dressing after excision of the shoulder-joint consists in the use of the Stromeyer cushion, applied between the arm and the chest, with its apex in the axilla. After excision of the shoulder-joint, as soon as the wound is healed, the fixation dressings should be removed, and the patient should carry the arm in a sling, and be encouraged to move it, as in this excision the formation of a false joint is most desirable.

Resection of the Humerus.—The whole or a portion of the humerus may require resection for injury or disease. The incision in this operation should be made upon the outer side of the bone, and carried down in an intermuscular space on a line with the shaft, great care being taken to avoid injury of the musculo-spiral nerve, which passes around the posterior surface of the humerus and lies close to the bone between the humeral heads of the triceps muscle, at a point corresponding to the deltoid insertion anteriorly—that is, about the centre of the shaft of the humerus. When the surface of the bone has been exposed, the periosteum should be divided to the length of the incision and carefully dissected loose from the bone with an elevator. The musculo-spiral nerve is isolated and held aside while the bone is being exposed. After separating the periosteum as completely as possible, if the whole shaft of the bone is found diseased, it may be removed in one piece, or by dividing it in the middle with a saw or forceps and removing each fragment as far as the upper and lower epiphyses, or the upper or the lower portion only may require removal. In resecting the humerus for an ununited fracture, the incision is made upon the outer surface of the arm over the seat of fracture, and when the latter has been exposed the fragments are separated and the end of each fragment is removed with a saw to obtain a fresh bone surface. The freshened ends of the bone are then drilled and united by heavy silver wire sutures, silver plates, or screws. The dressing after resection of the shaft of the humerus consists in the introduction of a rubber or gauze drain and the closure of the wound with sutures. A gauze dressing should be applied, and the arm placed upon a splint, and

subsequently fastened to the side of the body to secure fixation of the parts, or a plaster of Paris dressing may be applied.

Excision of the Elbow-Joint.—This operation may be required in cases of compound or gunshot fractures or tuberculous disease of this joint, and is occasionally employed to relieve the deformity and loss of function following unreduced dislocations or bony ankylosis of this articulation.

Fig. 560.

Incision for excision of the elbow-joint.

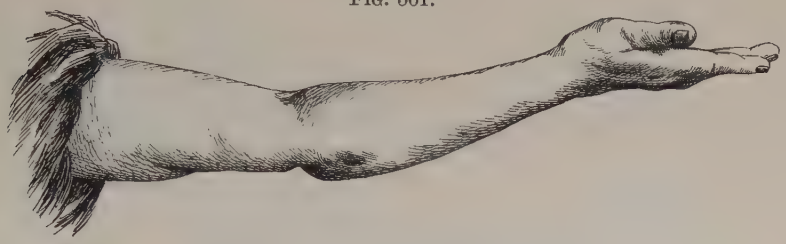
Operation.—In excising the elbow-joint, the forearm should be slightly flexed ; a longitudinal incision is made from about two inches above the olecranon process a little to its inner side, and carried three or four inches downward in the line of the ulna (Fig. 560) ; the tissues should then be divided down to the bone, and the ulnar nerve dissected from its groove behind the inner condyle of the humerus and held aside by a retractor. The tendon of the triceps muscle is next divided, and its attachment to the fascia and periosteum, over the olecranon process, is separated with an elevator or a periosteotome and turned downward, the capsule of the joint being opened and the lateral ligaments divided as the forearm is flexed upon the arm. The upper part of the ulna and the head of the radius are freed with a probe-pointed knife, and removed with a narrow-bladed saw, care being taken in making the section of the radius to divide its neck so that the attachment of the biceps muscle shall not be interfered with. The condyles of the humerus should next be freed and removed with a saw. In exposing the bones at the anterior portion of the joint, great care should be used to avoid injury of the brachial artery and vein and the median nerve.

In excision of the elbow-joint for disease, the amount of bone to be removed depends largely upon the extent of the disease ; the rule, however, is to remove the diseased bone freely, as better functional results occur after free removal than in cases where the bone has been removed sparingly. In excision for ankylosis, or for the deformity following unreduced dislocations, and in compound fractures of the elbow-joint, the same rule applies as regards the free removal of the ends of the bones.

After a sufficient amount of bone has been removed and hemorrhage has been arrested, the upper end of the divided tendon of the triceps should be fastened to the lower end or to its fascial expansion by a few sutures of chromicized catgut. A drainage-tube should be introduced, and the edges of the wound brought together with sutures. After applying a gauze dressing, a well-padded anterior angular splint should be placed upon the arm and forearm, with a moulded pasteboard gutter covering in the posterior surface of the elbow, and the splints held in place by a roller bandage. The plaster of Paris dressing may also be employed in these cases in place of the splints previously mentioned. If the wound runs an aseptic course it need not be dressed for a week or ten days, at which time the drainage-tube should be removed as well as the sutures, and the arm fixed in the same position for another week or ten days. As soon as the wound is firmly healed the splints should be removed, a light gauze dressing applied over

the region of the wound, and the patient allowed to carry the arm in a sling, and encouraged to pronate and supinate gently, as well as flex and extend, the forearm. In this excision it is desirable to have a fair range of motion, and with this end in view it is a mistake to retain fixation dressings for a

Fig. 561.



Extension of the arm after excision of the elbow.

long period; the sooner they are dispensed with and the patient begins to use the arm the better will be the functional result.

The result of an excision of the elbow-joint for an unreduced posterior dislocation with fracture of the inner condyle of the humerus, in which the arm was firmly fixed at a right angle and was both useless and painful, is shown in Figs. 561, 562. In this case the patient had both fair extension and flexion of the arm, and the motions of pronation and supination were perfect.

Fig. 562.

Flexion of the arm after excision of the elbow.

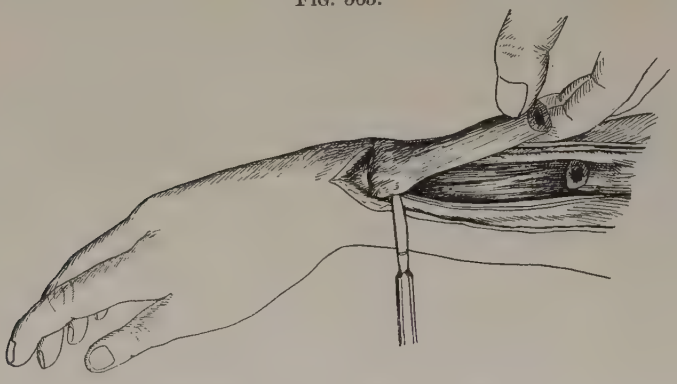
Resection of the Radius or Ulna.—Resection of the radius or ulna, either entirely or partially, may be required for disease or injury, or to correct deformity resulting from arrest of growth or from a loss of a portion of one or other of the bones.

Operation.—An incision should be made upon the back of the forearm over the bone to be resected; the bone being exposed, the periosteum is separated with an elevator, and the bone divided with a saw or bone forceps; each fragment is then lifted and separated from its muscular attachments up to the point where it is desired to remove it. (Fig. 563.) If the articular surface of the bone is to be removed, the disarticulation should be carefully made with a strong scalpel or a probe-pointed knife, and in exposing the anterior surface of the bone great care should be taken to avoid injury of the vessels and nerves lying upon its palmar surface.

Excision of the Wrist-Joint.—Excision of this joint may be required for injury, but is usually employed for tuberculous arthritis of the wrist-joint, which principally involves the carpal bones. The wrist-joint

has upon its posterior and lateral aspects skin, fascia, and tendons, and upon its anterior aspect, in addition to these structures, are important nerves

Fig. 563.

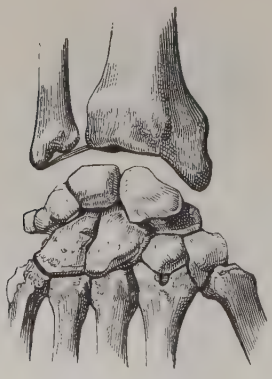


Resection of the lower end of the radius.

and blood-vessels. Their presence renders excision of this articulation an operation accompanied by more or less difficulty. (Fig. 564.)

Operation.—The wrist-joint may be excised by making a dorsal incision beginning at the middle of the ulnar border of the second metacarpal bone and carried upward about four inches (Fig. 565), crossing the ulnar edge of the tendon of the extensor carpi

Fig. 564.



Articulations of the wrist.

Fig. 565.

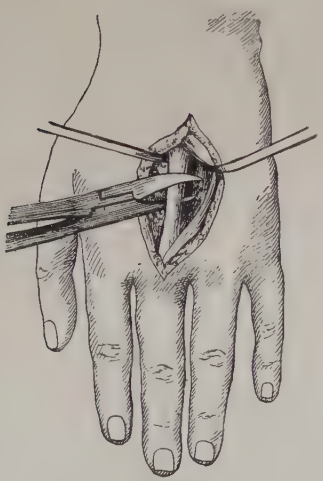
Incision for excision of the wrist. (After Stimson.)

radialis brevior and splitting the dorsal ligaments of the wrist between the tendons of the extensor secundi internodii and the extensor of the forefinger. The incision should be carried down to the bone, and the soft parts and tendons dissected loose with an elevator. By flexing the hand the first row of the carpal bones is made to present in the wound, and the scaphoid is separated from the trapezium and removed, the trapezium and pisiform being left if possible. In removing the second row of the carpal bones the knife should be passed between the trapezium and the trapezoid, and then into the carpo-metacarpal joint, cutting the ligaments of the dorsal side of the ends of the metacarpal bones, when the trapezoid, os magnum, and unciform can be taken away. The lateral ligaments are carefully divided,

and the articular ends of the radius and ulna divided with a saw; the ends of the metacarpal bones, if diseased, should next be removed. After the bones have been excised and the hemorrhage has been controlled, the wound should be drained and closed, a gauze dressing applied, and the forearm and arm secured upon a well-padded straight splint. As soon as the wound is healed the splint should be abandoned, as in this joint it is desirable to have a certain amount of motion. The patient should be encouraged to move the fingers, and also to make motions at the wrist to secure a movable joint.

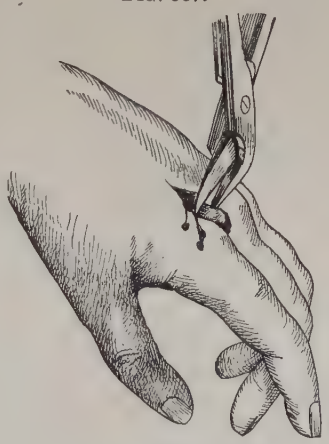
Resection of a Metacarpal Bone.—A metacarpal bone may be resected by making a longitudinal incision on the back of the hand over the bone to be removed. The incision should extend from one articular end of the bone to the other, and as it is deepened care should be taken not to divide the extensor tendons; these, when exposed, should be held to one side by a retractor, and, the periosteum being exposed, it should be separated as far as possible from the bone. When the bone has been fully exposed

FIG. 566.



Resection of a metacarpal bone.

FIG. 567.



Excision of a metacarpo-phalangeal joint. (Smith.)

it may be removed by dividing it at the middle with bone-cutting pliers (Fig. 566) and then disarticulating each fragment separately, or the articular ends may be disarticulated and the bone removed in one piece. All incisions employed in detaching the anterior surface of the bone should be made with great care, to avoid injury of the structures of the palm of the hand.

Excision of a Metacarpo-Phalangeal Joint or an Interphalangeal Joint.—In excising a metacarpo-phalangeal joint, the joint is exposed by a longitudinal incision over the dorsal surface of the knuckle. The extensor tendon being exposed and held to one side, the lateral ligaments are divided. The articular ends of the bones, being exposed, are next removed with a metacarpal saw or with bone-cutting pliers. (Fig. 567.) In excising an interphalangeal joint an incision may be made upon

the dorsal surface of the joint or upon its lateral surface, and after exposing the joint the lateral ligaments are divided. The articular surfaces of the bones are removed with a saw or with bone forceps.

Resection of the Clavicle.—Resection of this bone, either partial or complete, may be required for injury or disease. Disease of the clavicle arising from tuberculosis or infective osteomyelitis usually involves the shaft, so that the diseased portion extends only to the epiphyseal lines. The operation of complete or partial removal is occasionally required for sarcoma of the clavicle.

Operation.—The clavicle is resected by making an incision over the bone from one articulation to the other, which is carried directly down to the bone; the periosteum is then separated, the shaft of the bone divided at its middle, and each fragment raised with forceps and disarticulated (Fig. 568), or the bone may be disarticulated at one extremity, and, being raised up, be freed from its adherent tissues and disarticulated at the other extremity. In disarticulating the sternal end of the clavicle a probe-pointed knife should be used, and great care should be exercised to avoid injury of the important vessels and nerves which lie in close proximity to it.

FIG. 568.

Resection of the clavicle.

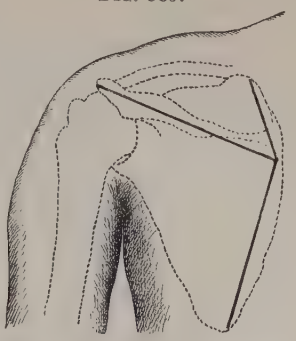
Resection of the Ribs.—Resection of the ribs may be required for injury or disease, and a partial resection of one or more ribs is frequently employed to secure free drainage in cases of empyema. The special operations employed for this purpose are described under Diseases of the Chest.

Operation.—In excising a rib the incision should correspond in length and direction with the portion of the bone to be removed, and may be crossed at each end by a short transverse incision; the tissues overlying the rib are then dissected loose, the periosteum is separated as far as possible, the rib is divided with cutting pliers at two points, and the piece is grasped with forceps, and removed by separating the attachments to its under surface with an elevator or a dry dissector. When this operation is not done to secure drainage from the chest, great care should be taken to avoid opening the pleural cavity.

Resection of the Sternum.—Resection of the sternum may be required for injury, for caries, or for sarcoma. The entire sternum has been removed, as well as the individual sections of the bone. Resection of the sternum is accomplished by making a longitudinal incision over the portion of the bone to be removed; after the periosteum has been exposed it should be carefully separated, and the diseased portion of the bone is then carefully freed from the attachments upon its posterior surface with an elevator, and is removed with forceps. After its removal a drainage-tube should be introduced, and a copious gauze dressing applied and held in position by strips of plaster placed so as to produce some fixation of the anterior portion of the chest.

Excision of the Scapula.—Excision of the scapula, either partial or complete, may be required for necrosis following injury, or for benign or malignant growths of the bone; in cases of malignant disease of the scapula a complete excision, as a rule, is the safer procedure, as partial excisions are very liable to be followed by a rapid recurrence of the disease. Complete excision of the scapula is both a difficult and a dangerous operation, the danger consisting largely in the amount of hemorrhage which occurs during its performance. When, however, the operation is done for necrosis, it is a comparatively simple one, and is not attended with great risk.

Fig. 569.



Incisions for excision of the scapula. (After Stimson.)

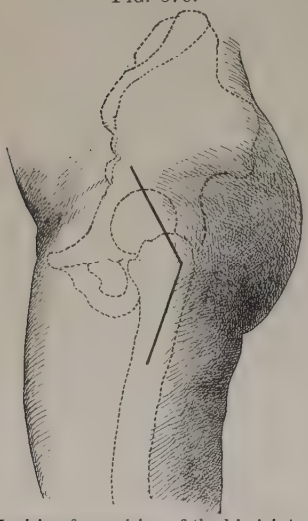
Operation.—In excising the scapula an incision should be made along the whole length of its spine; from the posterior extremity of this line two other incisions are made, one running about an inch or two above, and the other passing down the posterior border of the bone to its inferior angle (Fig. 569); the flaps thus made are loosened by separating the muscles attached to the outer surface of the bone. The attachments of the deltoid and trapezius to the acromion and spine of the scapula are separated, and the lower angle is freed by detaching the teres major and serratus magnus muscles. The bone is then raised, and the subscapularis muscle is detached from below upward. The neck of the scapula should next be divided with a chain saw or cutting forceps; the acromion is separated from the clavicle and scapula and turned upward, the joint being opened from below. The coracoid process should be separated from its muscular and ligamentous attachments, or may be divided with a saw and left in place. In clearing the supraspinous fossa care should be taken not to injure the suprascapular nerve in the suprascapular notch; to prevent injuring this nerve, it should be raised with a periosteotome in its fibrous sheath. As the great risk of this operation consists in the amount of blood that is lost during its performance, care should be taken that bleeding vessels are promptly secured with hæmostatic forceps as the operation proceeds, and when it is completed the vessels should be secured by ligatures. After excision of the scapula, one or more drainage-tubes should be introduced, the wound closed with sutures, a copious gauze dressing applied, and the arm securely fastened to the side with a Velpeau bandage.

Excision of the Hip-Joint.—Excision of the head of the femur may be required for gunshot injury or for compound comminuted fractures involving the head of the bone; the operation is, however, most frequently employed in cases of tuberculous arthritis of the hip-joint.

Operation.—In excising the hip-joint, an incision is made from a point about three inches below the crest of the ilium and about the same distance behind the anterior superior spine of the ilium, extending downward to the great trochanter, where it is carried forward in the line of the femur for three or four inches (Fig. 570); the soft parts are next dissected from the great trochanter and the upper part of the shaft of the femur, and the cap-

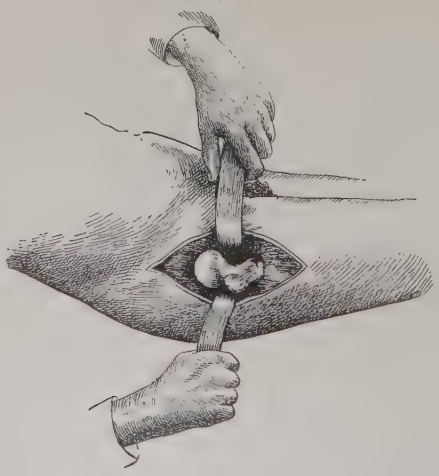
sule of the joint is opened. An assistant should next rotate the thigh inward and outward, and with a blunt-pointed knife the muscles attached to the trochanters are shaved off close to the bone; the head and neck of the femur are then freed by the use of a knife and the elevator; the thigh is adducted and pushed upward, and the head and neck of the bone are made to project from the wound. (Fig. 571.) A transverse section of the bone is then made with a saw or chain saw, just below the great trochanter. In some cases it is difficult to remove the head of the bone, which may be more or less firmly ankylosed to the acetabulum; here the neck of the bone should be divided with a chain saw passed around the femur just below the trochanter, or it may be divided with a narrow metacarpal saw from without inward, or with a chisel, the head and neck of the bone being afterwards removed with the gouge or bone-cutting pliers. After the head and neck of the bone have been removed, the acetabulum should be carefully examined, and if it be found carious the diseased bone should be removed with a curette or gouge, or with gouge forceps. If the acetabulum has been perforated and an abscess exists within the pelvis, the bony floor of the acetabulum should be cut away with a gouge, a curette being employed to clear out as far as possible the abscess-cavity, and a drainage-tube should be inserted into it. The edges of the incision should next be brought together by sutures, and a gauze dressing applied. The result of an excision of the hip-joint by this method is shown in Fig. 572.

Fig. 570.



Incision for excision of the hip-joint.

Fig. 571.



Exposure of the head of the femur in excision of the hip-joint.

Fig. 572.

Result of excision of the hip, showing amount of flexion of the thigh.

Anterior Excision of the Hip-Joint.—This method of excising the hip possesses the advantage that it divides no muscular fibres nor vessels of importance, and interferes very little with the capsular structures. It is especially indicated in the early stage of hip-disease and in those cases in which an abscess forms anteriorly. We have employed it in a number of cases, and consider it a most satisfactory method.

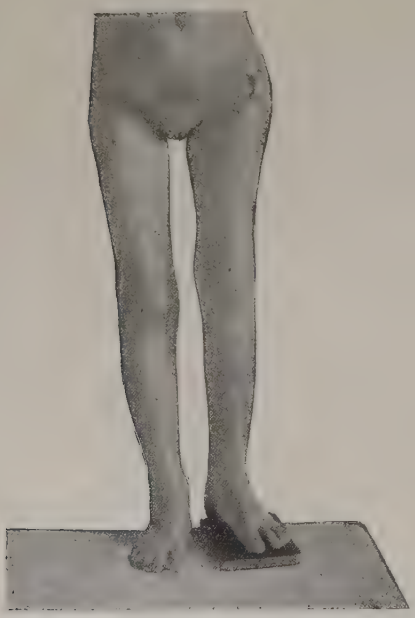
Operation.—In employing the anterior method of excising the hip-joint, an incision is made upon the front of the thigh over the joint, beginning half an inch below the anterior superior spine of the ilium, and carried three or four inches downward and a little inward; as the incision is deepened the tensor vaginæ femoris and the gluteal muscles are exposed, and should be drawn to the outer side; the sartorius and rectus muscles should be drawn to the inner side, when the neck of the femur is exposed; the neck of the bone is divided with a metacarpal saw or an Adams's saw, and the head of the bone is then grasped with strong sequestrum forceps, and by the use of these and an elevator it is removed; the acetabulum should then be examined, and if diseased bone is present it should be removed with a curette, as well as any diseased soft structures. The after-treatment of the wound consists in controlling bleeding, and, after thoroughly irrigating the wound, in filling its cavity with iodoform emulsion and closing the incision accurately with sutures. If drainage is desirable, a drainage-tube may be introduced into the bottom of the wound and allowed to project at some point upon the surface of the wound; we have, however, in those cases in which we employed drainage, found it more satisfactory, after excising the head of the bone, to make an opening through the tissues of the gluteal region and pass a drainage-tube from the acetabulum through this wound, closing the anterior one completely. The result of an anterior excision of the hip is shown in Figs. 573, 574.

After-Treatment.—This consists in the application of a plaster of Paris bandage extending from the foot to the pelvis, and including the leg, thigh, and pelvis, which gives complete fixation to the excised joint, or of an extension apparatus to the leg, to which a weight is attached, lateral support at the same time being given to the leg and thigh by the application of sand-bags, the limb being kept in an abducted position during the healing. As soon as the wound is healed a moulded pasteboard or a Thomas's splint should be applied, and the patient allowed to go about with crutches. The use of this splint is often required for some time to prevent flexion of the thigh upon the pelvis. After excisions of the hip-joint some surgeons prefer to keep the fixation apparatus applied for a considerable time, with the idea of obtaining bony ankylosis at the seat of operation, fearing that if motion is encouraged early greater shortening and deformity will result. We, however, are of the opinion that it is of decided advantage to have a fair range of movement in this joint after excision, and, with this end in view, encourage the patient to make motion at the joint as soon as the wound is healed, if it can be done without causing discomfort. If the splint is removed during the day, it should be worn at night if there is a tendency to flexion of the thigh upon the pelvis.

Excision of the Knee-Joint.—Excision of the knee-joint may be required for injury, for ankylosis in faulty position, or for disease, and the operation is most frequently resorted to in cases of tuberculous arthritis of this joint.

Operation.—The knee-joint is excised by making an incision which begins on the inner side of the limb, at the inner condyle of the femur, and

Fig. 573.



Result of anterior excision of the hip-joint.

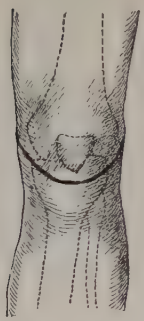
Fig. 574.

The same case showing the extent of flexion of the thigh.

is carried over the front of the knee, just below the patella, to a corresponding point upon the external condyle of the femur (Fig. 575); the flap thus formed, consisting of skin and connective tissue, is dissected up to a point corresponding with the upper edge of the patella. The ligamentum patellæ is then cut through transversely, the leg is slightly flexed, and the joint is opened; the lateral ligaments are next divided, and by flexing the leg upon the thigh the joint-surfaces are freely exposed. The semilunar cartilages are next removed, the condyles of the femur are freed posteriorly with a blunt-pointed bistoury, a narrow-bladed saw is placed under the condyles, and a transverse section of the bone is removed. (Fig. 576.) The head of the tibia is next cleared in the same manner, and a transverse section of this bone is removed with a saw. The patella may be removed before excising the ends of the bones, or, if ankylosed to the condyles, it may be removed with the section of bone which includes a portion of the condyles. After a sufficient amount of bone has been removed, if localized areas of carious bone present themselves upon the sawn surface of either bone, they

should be removed with a gouge or gouge forceps. In excising the knee-joint for ankylosis with flexion, a very large portion of the condyles and of the head of the tibia may require removal before the limb can be brought into a straight position, and if the deformity has existed for some time considerable contracture of the muscles may have resulted, requiring a division of the hamstring tendons before the deformity can be satisfactorily corrected.

Fig. 575.



Incision for excision of the knee-joint.

Fig. 576.

Excision of the knee-joint.

In such cases care should be exercised in making forcible straightening of the limb, to avoid rupturing the popliteal vein or popliteal artery. In excising the knee-joint in young persons care should be taken also to remove only so much bone as may be done without encroaching upon the lines of the epiphyseal cartilages, as injury of the latter will interfere with the subsequent growth of the limb. After sufficient bone has been removed to allow the limb to be brought into proper position, hemorrhage should be controlled by the application of ligatures, and fixation of the excised ends may be secured by introducing heavy silver wire sutures, steel nails, ivory pegs, or chromicized catgut or kangaroo sutures. Drainage need not be introduced into the wound, and the incision should be closed by sutures. After applying a gauze dressing to the wound the limb is enveloped in a flannel bandage and a plaster of Paris dressing applied from the foot to the groin. If for any reason it is considered desirable not to use this form of fixation dressing, after the wound has been dressed the limb should be placed upon a bracketed wire splint, which is fastened to the leg and thigh by straps and bandages, and the dressing is secured to the wound by a separate bandage. This allows the wound to be dressed, if necessary, without any disturbance of the bones. The result of an excision of the knee is shown in Fig. 577.

Excision of the Patella.--Excision of this bone may be required in cases of compound comminuted fractures, or for caries or necrosis. In the former class of cases no formal method of excision is practised, loose fragments being simply removed; when the operation is undertaken for disease, a longitudinal or crucial incision is made over the patella, the periosteum is

carefully separated from the bone, and the bone is grasped with strong forceps and dissected free from its attachments upon the under surface. The knee-joint is generally opened in excising the patella, unless the removal of the bone is undertaken for necrosis or caries, when it is possible to accomplish its complete removal without opening the joint. After excision of the patella the wound should be drained and closed by sutures, a gauze dressing applied, and the limb fixed in a straight position by the application of a posterior splint or a plaster of Paris dressing.

Fig. 577.

Result of an excision of the knee-joint.

Resection of the Tibia or the Fibula.—In resecting the tibia or the fibula, after the shaft of the bone has been exposed by a longitudinal incision, the periosteum should be separated as completely as possible, when the shaft may be removed in one piece or may be divided at its middle, each fragment being grasped with forceps, dissected up, and removed at its epiphyseal junction. (Fig. 578.)

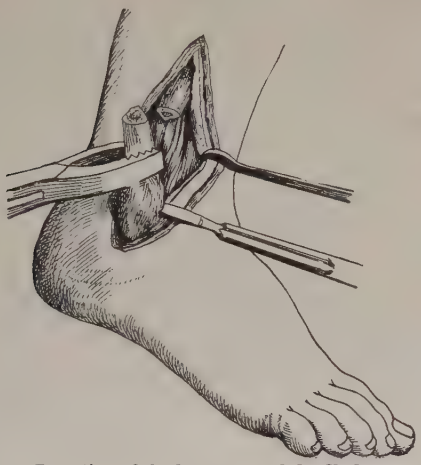
Excision of the Ankle-Joint.—This operation may be required for injuries of the ankle-joint, such as compound dislocations or fractures, or for tuberculous disease of the joint.

Operation.—In excising the ankle-joint an incision is made over the fibula at a point two inches above the joint and carried down to the tip of the external malleolus. The incision is then carried slightly upward towards the dorsum of the foot (Fig. 579), care being taken that it does not extend so far forward as to endanger the extensor tendons or the dorsal artery. The bone is exposed in this incision, and the periosteum is separated and turned aside; the peroneal tendons are next exposed and held to one side with retractors; the external malleolus is divided with bone-cutting pliers and removed, and the astragalus is exposed. The upper articulating surface of the astragalus is removed with bone forceps or with a saw, or the whole bone may be removed. The foot is then very much inverted, and the end of the tibia is cleared with a probe-pointed knife, being careful not to injure the posterior tibial artery, nerve, or vein, and when the articulating surface has been freed it is removed with a saw or bone forceps. The articular end of the tibia may be exposed by making an additional incision upon the inner side of the ankle, over the internal malleolus if it is desired. After the joint has been excised a drainage-tube should be introduced, the incision closed with sutures, and a gauze dressing applied. The foot is placed at a right angle to the leg and a plaster of Paris bandage applied to the foot and leg, or fixation may be given to the parts by the application of moulded binders' board splints. The latter method of fixation is preferable if frequent dressings of the wound are necessary. After excision of the ankle in some cases more or less movement of the joint remains, while in others bony ankylosis results. In

either event the result is apt to be satisfactory as regards the usefulness of the part.

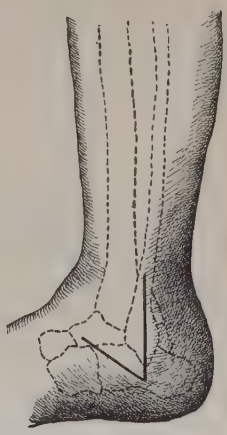
Excision of the Astragalus.—Excision of this bone may be required for compound fractures or dislocations or for tuberculous disease of the tarsus, and is often employed to correct the deformity in aggravated forms of club-foot. In excising this bone an incision is made on the outside of the ankle-joint, very similar to that employed for excision of the ankle-

Fig. 578.



Resection of the lower part of the fibula.

Fig. 579.



Incision for excision of the ankle-joint.

joint; the external lateral ligaments are divided, and the astragalus is exposed by forcibly inverting the foot; the bone is then seized with strong forceps, its ligamentous attachments are divided with a probe-pointed knife, and it is removed. The dressing consists in introducing a drainage-tube if it is considered necessary, closing the wound with sutures, and applying a gauze dressing, after which the foot should be secured in a position at a right angle to the leg, by means of a plaster of Paris bandage, covering the foot and leg, or by moulded splints of binders' board secured by a bandage. The functional result after excision of the astragalus is usually very satisfactory.

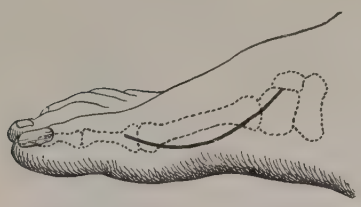
Excision of the Os Calcis.—Excision of the os calcis may be required in cases of compound fractures of this bone, or for caries or necrosis.

Operation.—In excising the os calcis an incision is made beginning at the upper part of the bone at the inner border of the tendo Achillis, which passes around the back and outer surface of the foot, dividing this tendon, to the base of the fifth metatarsal bone; a short incision is then made at the anterior end of the first incision, and carried down to the sole of the foot; the bone is exposed and held by forceps, and the flap thus formed, which includes the peronei tendons, is separated from the bone; the cuboid ligaments are divided, as well as the interosseous ligament between the os calcis and the astragalus, and the bone is then removed with forceps. The ends of the divided tendo Achillis should then be brought together with a few

sutures, and the wound closed and drained, and, after a gauze dressing has been applied, the foot and leg should be included in a plaster of Paris dressing. The deformity resulting after excision of the os calcis is very marked, but if the operation has been a subperiosteal one the function of the muscles exerted through the tendo Achillis may be more or less retained. We have resorted to excision of the os calcis in a case of compound comminuted fracture of the os calcis and in a case of necrosis following frost-bite, and in both the functional result was very satisfactory.

Resection of the Metatarsal Bones.—Resection of these bones may be required for disease. The operation is performed by making an incision on the dorsum of the foot over the bone to be removed; the bone being exposed, and the extensor tendons being held aside by retractors, it is disarticulated at either end, or is cut in its middle and each fragment dissected up and removed at its articulation. The metatarsal bone of the great toe is exposed by making a curved incision over that bone on the inner side of the foot. (Fig. 580.)

Fig. 580.



Incision for excision of the metatarsal bone of the great toe. (Smith.)

Excision of the Coccyx.—Excision of this bone may be required for disease or for a painful neuralgic condition known as coccygodynia. In removing the coccyx the finger should first be passed into the rectum and the position of the bone determined; a longitudinal incision through the skin and fibrous tissue covering the coccyx is next made, beginning about a quarter of an inch above its upper limit, and is carried down to the bone, extending a little below its lower extremity. The incision is deepened until the surface of the bone is exposed, and retractors are applied, so as thoroughly to dilate the wound; if it is found that more space is needed, the incision may be supplemented by a transverse one. The sacro-coccygeal articulation is next carefully opened, and an elevator is introduced into the articulation and the bone raised and grasped with forceps; it should then be separated from its lateral attachments, and from those upon its anterior surface, with a knife and an elevator. As the wound resulting from excision of this bone is a deep one, it is well to introduce a drainage-tube before bringing the edges of the wound together with sutures. After applying a gauze dressing, which is held in place by broad strips of adhesive plaster, the patient should be kept at rest upon the side or the back, and the bowels should be kept quiet for a few days.

Excision of the Upper Jaw.—Excision of the upper jaw may be required on account of necrosis of this bone or for malignant or non-malignant growths, or may be employed to facilitate the removal of naso-pharyngeal tumors. The operation is one attended with considerable hemorrhage, which may itself cause a fatal issue; but if this is not excessive, union of the parts after the bone has been excised is usually rapid, and the resulting deformity is much less than would be expected from so serious a mutilation. When the operation is performed for sarcomatous or carcinomatous growths springing from the upper jaw, a permanent cure is seldom effected,

as recurrence sooner or later takes place in the adjacent tissues, but the patient's life is often prolonged and made much more comfortable by the operation. When, however, the operation is undertaken for exposure of retropharyngeal growths, if possible, an osteoplastic resection of the jaw should be preferred to an excision.

Operation.—In excising the upper jaw the incision is begun half an inch below the inner canthus of the eye, and is carried downward along the line of junction of the nose and face, and then downward to the free border of the lip; it is also advisable to carry the incision along the lower edge of the orbit outward over the malar bone. (Fig. 581.) This flap having been dissected away from the surface of the bone, a small narrow metacarpal saw should be applied to the floor of the nostril until a deep groove has been made; the soft palate should next be divided from within the mouth with a

FIG. 581.

Incision for excision of the upper jaw.

FIG. 582.

Excision of the upper jaw. (Agnew.)

strong knife, and one or two incisor teeth being removed, and one blade of a pair of strong bone-cutting pliers introduced into the floor of the nose, in the line of the saw incision, and the other into the mouth, in the line of the division of the structures of the palate, the bone should be divided. The hard palate and other connections of the bone may be divided with a chisel. The malar bone should next be divided with a saw or forceps (Fig. 582), and finally the blades of a strong pair of bone-cutting forceps should be introduced, one into the nostril and the other at the edge of the orbit, the important structures of the orbit being held upward with a retractor, and the inner angle of the orbit cut across; the bone is then grasped with strong lion-jawed forceps and twisted out, any bands of tissue which hold being divided with a knife or scissors. The most serious hemorrhage is apt to result from division of the internal maxillary artery; this may be grasped with hæmostatic forceps and secured by a ligature, or, if it is impossible to seize the bleeding vessel, the hemorrhage may be controlled by the actual cautery. After the bleeding has been arrested, the edges of the incision should be brought accurately together by sutures, and a pad of iodoform gauze placed in the cavity of the cheek.

Osteoplastic Resection of the Upper Jaw.—Osteoplastic resection of the superior maxillary bone by Langenbeck's method consists in

making first an incision from the inner angle of the orbit to the malar bone, and a second incision from the nostril to the malar bone, joining the first. The soft parts are left adherent to the bone, which is divided with a saw upon the line of both incisions to the retromaxillary fossa; when this is accomplished the bony flap thus made is bent over the central line of the nose and drawn towards the opposite cheek; this exposes the naso-pharyngeal cavity in the retromaxillary space. After the tumor has been removed and bleeding has been controlled by ligatures or the cautery, the parts are returned to their normal position and secured by a few sutures introduced into the bone, and by sutures introduced through the edges of the wound in the soft parts.

Excision of the Lower Jaw.—Complete or partial excision of the lower jaw may be required for injury or for disease of this bone. The whole of the lower jaw, one-half of the jaw, or the anterior portion, including the symphysis, or a portion of the alveolus only, may require removal.

Excision of the Ramus and Half of the Body of the Lower Jaw.—Operation.—In excising this portion of the bone an incision should be made from a point just below the free border of the lip, over the symphysis, and carried down to the lower border of the jaw, from which point it extends along the ramus to the lobe of the ear. (Fig. 583.) This flap is then dissected up, separating the masseter muscle from the bone as far as possible without opening the cavity of the mouth. An incisor tooth is next extracted, and the bone is divided with a saw near the symphysis. The jaw is then seized with forceps and drawn downward and outward, and denuded upon its inner surface. The insertion of the temporal muscle into the coronoid process is divided, the condyle of the jaw is disarticulated from the glenoid cavity, and the remaining soft parts are carefully detached with a knife or an elevator. (Fig. 584.) The facial artery and the inferior dental nerve and artery are necessarily divided in removing this portion of the jaw.

Fig. 583.

Incision for excision of the lower jaw.

When the operation is performed for necrosis of the bone, the periosteum should as far as possible be preserved, but in cases of malignant disease it should be removed with the bone. If the middle portion of the lower jaw is taken away, removing the symphysis, the attachments of the muscles inserted into the genial tubercle are divided, and the tongue falls backward. To prevent this accident, before the attachments are severed a strong silk ligature is passed through the tip of the tongue, which is held forward and secured in this position until adhesions have formed. After removal of the whole or a portion of the lower jaw, the edges of the wound should be brought together with sutures, a pad of iodoform gauze loosely

packed into the cavity left by removal of the bone, a gauze dressing applied over the line of incision, and held in position by an oblique bandage of the jaw.

Partial Excision of the Lower Jaw or of the Alveolus.—Removal of a portion of the alveolar process of the jaw, or of a portion of the body of the jaw, necessitated by necrosis of the bone, can often be accomplished without the aid of a cutaneous incision. The jaws should be separated with a mouth-gag, an incision made through the tissues covering the bone, an elevator introduced, and the bone gradually loosened from the periosteum and removed with forceps.

FIG. 584.

Excision of the lower jaw. (Agnew.)

Removal of the Condyle of the Jaw.—This may be accomplished by making an incision close in front of the temporal artery and carrying it forward along the zygoma for an inch and a half; the tissue being divided and the bone exposed, a second incision, involving only the skin, is carried from the centre of the first incision directly downward for about an inch, the soft parts being carefully separated with a knife and an elevator from the margin of the zygoma and the outer surfaces of the joint, and drawn downward with a retractor to prevent injury of the parotid gland, nerves, and vessels. The neck of the condyle is then cleared by working around it in front and behind with a director, keeping close to the bone to avoid injury of the internal maxillary artery. A chain saw should then be passed around the neck of the bone, with which it is divided, and the condyle is seized with forceps and removed with an elevator or a gouge.

ARTHRECTOMY, OR ERASION.

This operation has recently been introduced as a substitute for excision or resection in the treatment of diseases of the joints, and has been frequently resorted to in the treatment of tuberculous arthritis. It consists in exposing the joint by an incision similar to that which would be employed for excision of the joint, and after the joint surfaces are exposed the diseased synovial membranes, cartilages, and carious deposits in the articular surfaces of the bone are removed with forceps and scissors, or with a gouge or curette; no extensive removal of bone is practised. After all the diseased structures have been removed, the wound is irrigated and dusted with powdered iodoform, a drainage-tube introduced, and the wound closed, deep sutures being used to bring together the capsular ligament, and a line of superficial sutures employed to close the skin incision. This operation seems especially applicable to the treatment of disease of the joints in young persons, as it involves no risk of injury of the epiphyseal cartilages. The results of arthrectomy have been fairly successful in tubercular disease, some cases recovering with movable joints; in others more or less contraction and fixation result from the operation. If recurrence of the disease takes place, an excision of the joint may be performed later.

Erasion has been more frequently practised in diseases of the knee-joint than in any other articulation, owing to the fact that in this joint the diseased joint surfaces can readily be exposed by a simple incision; but it may be employed in other articulations. Erasion of the elbow-, shoulder-, or ankle-joint is a more difficult operation, because of the greater complexity of structure of these joints.

Arthrectomy of the Knee-Joint.—The joint should be exposed by a transverse or slightly curved incision across the front of the joint over the tendo patellæ, similar to that employed in excision. The tissues should be divided and the joint opened, the tendo patellæ being divided transversely, and upon flexing the leg the articular surfaces will be freely exposed. The diseased synovial membranes and articular cartilages should then be carefully removed with scissors or with a curette, the patella being turned up and its under surface carefully inspected. If the semilunar cartilages are extensively diseased they should be removed, as well as any tuberculous deposits in the bone. After all the diseased structures have been removed the joint should be thoroughly irrigated and dusted with powdered iodoform, drainage-tubes introduced, and the capsular ligament and the ends of the severed tendo patellæ securely brought together with catgut or silk sutures. The superficial portion of the wound should next be approximated with sutures, and a gauze dressing applied. After the wound has been dressed, the foot, leg, and thigh should be fixed in a plaster of Paris bandage. Even after the wound has solidly healed, to prevent the tendency to contraction of the knee, a plaster of Paris bandage, or a fixation splint of leather, or a metallic brace, should be worn for some months.

OSTEOTOMY.

This operation consists in making a section of a bone with a saw, an osteotome, or a chisel, and has of late years been widely and successfully employed to correct deformity in the bones. The operation may be done subcutaneously—that is, a small puncture is made with a knife just sufficient to admit the saw or the osteotome, and the bone is then divided—or may be practised as an open one, a flap of the soft parts being turned up to expose the bone, which is subsequently divided.

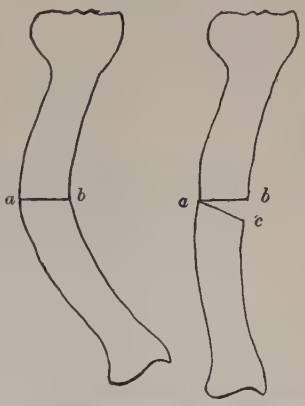
Osteotomy may be either *linear*, when a simple linear section of the bone is made, usually subcutaneously, or *cuneiform*, when a wedge of bone is removed by a chisel, the open operation being employed in this case. In linear osteotomy, when the section of the bone is made with the osteotome or the saw and the correction accomplished, a gap is left to one side of the bone, which is subsequently filled up with new bone. (Fig. 585.)

The instruments required for osteotomy are osteotomes of various sizes (Fig. 586), a narrow saw with a short cutting surface and a long narrow shank, Adams's saw (Fig. 587), a stout tenotome, and a mallet. The osteotome or chisel is the instrument most frequently used.

Linear Osteotomy.—The skin of the part to be operated upon should be carefully sterilized, and a short flat sand-bag covered with a bichloride towel laid under the limb. A small incision is next made down to the bone at the point where it is to be divided, and the osteotome or saw is

introduced. If the osteotome is used, it is driven carefully through the bone with strokes of the mallet, being held as shown in Fig. 588. If the saw is employed, the bone is carefully divided by short strokes. It is not always necessary to divide the bone completely; a small portion of the posterior surface may be left undivided, the osteotome being withdrawn, and the remaining portion of bone fractured by manual force. This procedure is a safer one than complete division when large vessels lie in close contact with the posterior surface of the bone.

Fig. 585.



Linear osteotomy: *ab*, line of section of the bone; *abc*, gap left after correction of the deformity.

Cuneiform Osteotomy.—In this operation a wedge-shaped piece of bone is removed with a chisel or with a saw. The mechanism of the correction of the deformity by this operation is shown in Fig. 589.

The limb is placed upon a sand-bag, and the bone is exposed by turning up a flap, or by a transverse incision, and retracting the soft parts. A wedge-shaped section of bone, of sufficient size to permit of the correction of the deformity, is then removed. This operation is most frequently employed in cases of anterior tibial curvature,

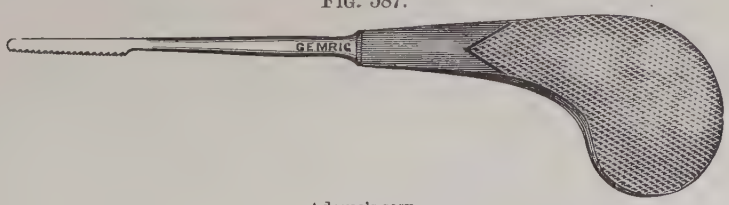
Fig. 586.

Osteotome.

and for the correction of deformities of the knee and jaw, and occasionally in cases of club-foot.

After-Treatment.—The small wounds in subcutaneous osteotomy are covered with a compress of iodoform gauze or with a scab of gauze and iodoform collodion, and in cuneiform osteotomy the edges of the flap or of the incision should be held in position by sutures and covered with a steril-

Fig. 587.



Adams's saw.

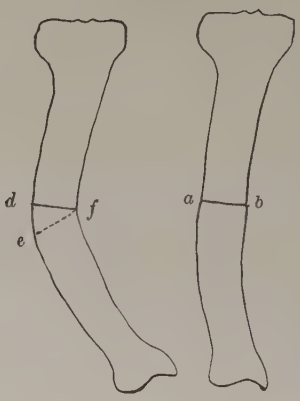
ized or iodoform gauze dressing. A pad of cotton is placed over the dressing, the bony prominences are also padded, a flannel bandage is applied to the whole limb, and while the limb is held in the corrected position a plaster of Paris bandage is applied to the part. This dressing is usually allowed to

remain for a month, when it is removed and a lighter one applied for a few weeks longer, union of the bones generally being quite firm at the end of eight weeks; but it is wise to give support to the parts by light splints for some time longer.

Fig. 588.

Method of holding osteotome.

Fig. 589.



Cuneiform osteotomy: *def*, wedge of bone removed; *ab*, line of approximation of the bone surfaces after the removal of the wedge.

The principal danger in this operation arises from infection of the wound, or from injury of important blood-vessels or nerves. The former danger can be avoided by care as regards asepsis at the time of operation, and injury of the blood-vessels and nerves is an unusual accident if the bone is divided carefully and slowly.

CHAPTER XXIII.

ORTHOPÆDIC SURGERY.

THIS branch of surgery deals with the prevention or correction of deformities, either by the use of mechanical appliances or by operative procedures, and the choice of the method adopted in any individual case depends upon the judgment of the surgeon. Excellent results may follow either of these methods in well-selected cases. The deformities which require correction may be either congenital or acquired. **Congenital** deformities consist in a large proportion of the cases of deformities of the hands and feet, including most of the cases of club-foot, those of the hip and shoulder from arrest of development of the acetabulum or of the glenoid cavity, some cases of wry-neck, and arrest of development of the limbs. Such congenital deformities as harelip, cleft palate, exstrophy of the bladder, imperforate rectum, etc., are sometimes considered as coming within the domain of orthopædic surgery, but in the present work they are not included under this head. **Acquired** deformities may result from injuries, but are in most cases due to tuberculosis of the bones or joints, to rickets, or to paralyses of muscles, which may be cerebral, spinal, or peripheral in origin. The fact that deformities result from these diseases should always cause the surgeon to employ such means in their treatment, both mechanical and operative, that deformity shall be, as far as possible, avoided. Orthopædic surgery, therefore, should not be limited to the correction of deformities, but should be extended to their prevention.

TORTICOLLIS, OR WRY-NECK.

Torticollis, or wry-neck, is a deformity in which the head is held in a distorted position through the abnormal action of certain of the neck muscles. It occurs in both sexes, and is occasionally congenital, but generally comes on gradually during early childhood. The so-called congenital form may be of prenatal origin, but is usually due to an injury during labor, affecting either the nerve-centres or the muscles. The acquired form arises from several causes: it may be due to *paralysis* of the opposing group of muscles, to an injury to the muscles, or to a growth in the sterno-cleido-mastoid, as a gumma or a sarcoma, or it may be compensatory, following a primary lateral curvature in the dorsal spine. The *torticollis oculaire* of Quignet is due to an effort to overcome an inequality in the strength of the eyes. A majority of the cases, however, are spastic, in some of which a direct cause can be discovered, as a central nervous lesion, or some source of peripheral irritation, as abscess of the neck or enlarged cervical glands; while in very many cases, one of the eruptive fevers, severe mental shock, or hysteria,

may be the exciting cause. There is an acute form, coming on suddenly, with local rheumatic symptoms, pain and stiffness, and some constitutional disturbance, which occasionally becomes chronic. An intermittent variety of nervous origin is observed, especially in adult females, and is either tonic or clonic in type, and sometimes choreiform. The sterno-cleido-mastoid is the muscle most often affected, although seldom alone, the trapezius being frequently involved with the latter muscle, both being supplied by the spinal accessory nerve. The splenius, scaleni, platysma, and complexus are sometimes found to be contracted. The sterno-mastoid of one side when contracted turns the head to the opposite side and elevates the chin. (Fig. 590.) Unilateral contraction of the trapezius and deeper muscles of the neck draws the head backward and down towards the shoulder of the affected side. The muscles in the later stages undergo fibrous change, becoming hard and rigid. Attempts at reposition sometimes cause pain, which is not, however, a frequent symptom in the ordinary cases. A compensating lateral curvature takes place in the dorsal spine, and a curious asymmetry of the face develops in long-standing cases. It consists in atrophy of the features on the affected side, with deviation in the line of the nose, a difference in level of the eyes, and asymmetry of the cranium.

Fig. 590.

Torticollis, or wry-neck.

Treatment.—The treatment is therapeutic, mechanical, and operative. In the acute variety the administration of salicylate of sodium, morphine, and atropine, the latter hypodermically, and local applications of heat, may be of service. In paralytic cases means should be taken to restore power to the paralyzed muscles by electricity and the hypodermic injection of strychnine. In the intermittent type careful attention must be paid to the underlying conditions, treatment being directed to improving the general health and the condition of the nervous system. In cases associated with reflex irritation, as enlarged cervical glands, and with ocular troubles, treatment should be directed to these conditions. Mechanical appliances are of value after operative treatment and in paralytic cases. The simplest device is that suggested by Little, consisting of a strip of adhesive plaster around the head and another around the thorax, traction being made by a bandage fastened to the first at the side of the head, running across the chest, and fastened to the second at the opposite side. More complicated appliances are those of Sayre, Buckminster-Brown, and others. *Operative* treatment is generally necessary in the ordinary chronic cases. *Subcutaneous tenotomy* and *open incision* are the operations employed where there is persistent contraction of the sterno-mastoid. One or both heads of the muscle may be divided by either the subcutaneous method or open incision. Open incision should be preferred, as there is less risk of injuring the vessels and the contracted tissues can be thoroughly divided,

which cannot always be done with safety subcutaneously. **Subcutaneous tenotomy** is performed by making a puncture down to the tendon on the inner side and introducing a blunt-pointed tenotome beneath the tendon and cutting outward. **Open incision** is best performed by making the incision parallel with and one inch above the clavicle. It permits of thorough division of all resisting structures. In both operations care must be taken to avoid wounding the anterior and internal jugular veins and the carotid artery, as several deaths from this operation have been due to hemorrhage. After tenotomy the head should be placed immediately in a position of over-correction and held there by plaster of Paris or other means for a couple of weeks, when a permanent apparatus can be applied, to be worn until cure is complete. (Fig. 591.) In cases due mainly to contraction of the posterior muscles, division of these is often difficult or even impossible, and forcible correction under ether is recommended by Bradford and Lovett. Spinal caries, which simulates this form of wry-neck, must first be carefully excluded. In the intermittent, spasmodic cases tenotomy or open incision is of little use, and the best results are obtained by division and resection of the spinal accessory nerve. The upper cervical nerves have also been resected in this form of wry-neck with success in some cases.

Fig. 591.

Apparatus after operation for wry-neck. (Dr. G. G. Davis.)

Fig. 592.

Normal curves of the spine. (Agnew.)

CURVATURES OF THE SPINE.

The natural curves of the spinal column are antero-posterior, with a slight lateral tendency at the upper part of the dorsal region. In the cervical region the curve is concave behind and convex in front; in the dorsal region the concavity is anterior and the convexity is posterior; while in the lumbar region the concavity is posterior and the convexity is anterior. (Fig. 592.)

The pathological curvatures of the spine are *scoliosis*, or lateral curvature; *kyphosis*, an antero-posterior curvature with the convexity backward; and *lordosis*, an antero-posterior curvature with the convexity forward.

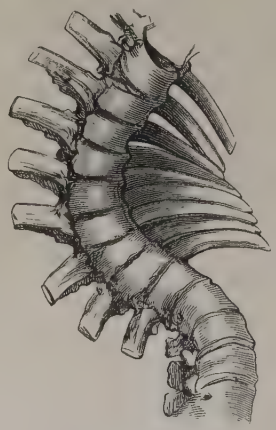
Lateral Curvature (Scoliosis).—In this affection the spine describes two or more lateral curves, with their convexities on opposite sides of the longitudinal axis of the back; at the same time the relations of the vertebræ to the same axis are changed by rotation, so that the spinous processes point towards the concavities of the lateral curves. If the primary curve is in

the lumbar region, and directed to the left side, the compensating curve will be in the dorsal region, and will be in the opposite direction, or to the right side, and a third compensating curve will be observed in the cervical region (Fig. 593), with its convexity in the same direction as the original lumbar curve. These compensating curves arise from the necessity of maintaining the erect position.

Fig. 593.

Primary and secondary lateral curvatures. (Agnew.)

Fig. 594.



Position of ribs and vertebræ in lateral curvature. (Agnew.)

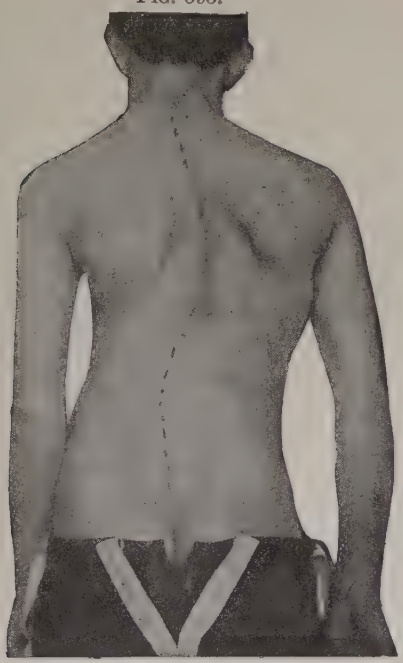
The intervertebral cartilages in the region of the curves are compressed and become wedge-shaped, with their bases towards the convexity of the curve. The ribs in dorsal curves are crowded together upon the concave side, and upon the convex side are widely separated (Fig. 594), the scapula is carried forward with them, making a hump, and the thorax is much distorted. Lateral curvature begins most frequently in the dorsal region, and commonly involves the right side.

Causes.—A great variety of causes may lead to lateral curvature of the spine. Among the predisposing causes may be mentioned congenital asymmetry, general weakness, rapid growth, and rickets, which affects the structure of the bones, diminishing the resisting power necessary to withstand the effects of pressure and of muscular action. The principal exciting causes are habitual one-sided positions of the body, resulting from an improper method of carrying children, and later in subjects between twelve and twenty years from sitting at desks in school for hours with the body inclined to one side, or from carrying heavy weights upon one side of the body. Obliquity of the pelvis from one limb being shorter than the other may cause lateral curvature. Unilateral muscular atrophy resulting from changes in the central nervous system or from undue exercise of the muscles of the opposite side, or unilateral muscular hypertrophy from overuse of the muscles of one side, or spasm of the muscles from disease of the central nervous system, draws the spinal column to the side of strongest muscular contraction. Empyema may cause lateral curvature by the contraction of the walls of the thorax, and sacro-iliac disease, as well as morbid growths of the trunk and pelvis, may also give rise to lateral distortion of the spinal column. It should not be forgotten that in rare cases tuberculosis of the lateral portions of the bodies of the vertebræ causes lateral curvature of the spine.

Symptoms.—In the early stages of this affection the symptoms may not be marked: the patient may notice, if a boy, that the suspenders have a tendency to slip off one shoulder, and, if a girl, the dressmaker may notice that it is difficult to fit the dress upon one side. The patient in stooping

often complains of pain in the dorsal or the lumbar region, or of weakness of the back. If the patient is stripped of clothing and made to stand before the surgeon, if the curvature is in the dorsal region the lower angle of one or other of the scapulæ or the iliac crests is unduly prominent. If the tips of the spinous processes are marked with chalk or a pencil, the line of curvature can be distinctly demonstrated (Fig. 595); the shoulder upon the affected side is unduly elevated, and the breast on one side may be more prominent than its fellow. The limbs may also present asymmetry, shown

FIG. 595.



Lateral curvature of the spine. (Sayre.)

FIG. 596.

Lateral curvature of the spine associated with rachitic deformities.

by obliquity of the pelvis when the patient stands. In lumbar curvature, if the patient bends forward, with the arms hanging loosely, the erector spinæ muscles become more prominent on the convexity of the curve. In dorsal curvature the angles of the ribs on the side of convexity are on a higher level than on the side of concavity. (Fig. 596.)

Lateral curvature is likely to be confounded only with hysterical curvature of the spine, which entirely disappears if the patient is made to stoop forward until the fingers touch the floor, and with tuberculosis of the lateral aspects of the bodies of the vertebræ, which may cause lateral curvature of the spine; but the latter condition is associated with rigidity of the spine and other symptoms of Pott's disease, so that it is not difficult to recognize the true nature of the affection.

Treatment.—In the treatment of lateral curvature of the spine systematic exercise of the muscles of the trunk holds the first place as a curative measure. In addition to regulated gymnastic exercise, intervals of rest

in the recumbent posture and good hygiene are important factors in attaining a good result in the treatment of these cases. Self-suspension by the arms from a bar, or suspension by means of a Sayre head-piece, combined with pressure upon the convex side of the curve, are often employed with benefit. As a rule, the use of steel braces or the plaster of Paris or leather jacket is not required, and often if employed does more harm than good, except when used as will be described later. Massage of the weakened spinal muscles is a valuable agent, and should be combined with systematic exercises.

The use of spinal braces is often much abused, but we have seen many cases where they proved valuable agents in the treatment, used in connection with massage and gymnastics and recumbency; in such cases they should be worn only at short intervals; for instance, in lateral spinal curvature we order the patient systematic gymnastics with massage, and rest upon the back on a firm couch, with the head low, at certain times during the day. If the deformity is marked, we have the patient suspended, and apply a plaster of Paris jacket while in this position, and as soon as it is firm it is split down the front, so that it can be removed; eyelets are fastened to this, so that it can be reapplied, or we have made from this cast a leather jacket. This jacket is applied and worn for a few hours each day while the patient is taking out-door exercise, being removed during the gymnastics and while the patient is recumbent. A steel brace may be worn in the same way. Used in this manner, spinal braces may be of great service in the treatment of lateral curvature of the spine, but, as before stated, they are not required in most cases. In cases of lateral curvature due to inequality in the length of the limbs, a high shoe on the short leg will often correct the deformity. In addition to local treatment previously mentioned, good diet, regular meals, tonics, exercise in the fresh air, and a change of climate, when it is possible, are all means which may very materially aid in bringing about a cure of the affection.

Posterior Curvature of the Spine (Kyphosis).—This affection is usually seen in young children, and is the result of rickets, or develops in weak and anæmic children who are compelled to sit without proper support to the back. It is often seen in older children in the same class of patients that present lateral curvature of the spine. Kyphosis may also result from occupation: tailors, shoemakers, and other workmen who are employed continuously with the back bent are apt to develop this form of spinal curvature.

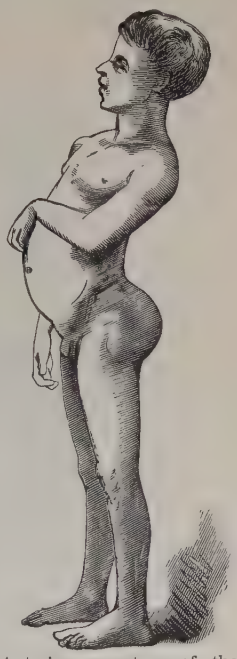
The condition results from relaxation of the vertebral ligaments and spinal muscles, which is accompanied by separation of the laminæ and spinous processes, and in aggravated cases there may be absorption of the intervertebral disks and of a portion of the bodies of the vertebræ.

This disease is likely to be confounded with the kyphosis of tuberculous disease of the vertebræ, but may be distinguished from this affection by the facts that in the early stages of the disease there is no rigidity, and that the curve is a general one and does not present an angular projection at one point (see page 547), as is the case in Pott's disease; it is most common in infants and young children, in whom it is due to rickets, and they present other evidences of the disease. When seen in adults it usually

results from occupation, and may be confounded with osteo-arthritis of the vertebræ or spondylitis deformans.

Treatment.—Kyphosis due to rickets should be treated by rest in the recumbent posture, by massage of the weak spinal muscles, and by the use of the constitutional treatment appropriate for that disease. In older patients, when rickets is not the cause of the affection, massage, systematic exercise, and the abandonment of the vicious posture will often result in the relief of the deformity. The use of the spinal brace is rarely required.

Fig. 597.



Anterior curvature of the spine. (Agnew.)

Anterior Spinal Curvature, or Lordosis.—This affection may occur as the result of rickets, or from relaxation of the anterior spinal ligaments, or from disease affecting the posterior portion of the vertebræ, and is often observed as a compensating curve in tuberculosis of the spine, or in hip-disease. (Fig. 597.) In congenital dislocation of the hip, marked lordosis is a prominent feature of the deformity. It is often observed in acrobats who acquire preternatural mobility of the lumbar spine. It may also result from paralytic conditions, as infantile palsies or pseudo-hypertrophic paralysis.

Treatment.—When lordosis is a compensating deformity to bring the upper part of the spine back to the centre of gravity, no special treatment is indicated, but the primary affection which causes the lordosis should receive attention. When it results from rickets, recumbency and tonics with proper diet are indicated; when it results from paralytic conditions, the employment of massage and galvanism may be followed by good results. The use of supporting apparatus, such as a leather or a plaster of Paris jacket, while the child is taking exercise, but not continuously, is often of marked benefit.

KNOCK-KNEE, OR GENU VALGUM.

Knock-knee, or genu valgum, is a deformity which consists in an angular projection of the knee inward. It is a common deformity, and may be either single or double. (Fig. 598.) It arises especially in children beginning to walk, as a result of rachitic disease of the bones, and develops more rarely during adolescence, the *genu valgum adolescentium*, which, according to Mikulicz, is due to latent rickets, although this is denied by many. The deformity depends partly on the muscles and ligaments and partly on the bones entering into the formation of the joint. In the rachitic form the bones are especially affected, while in some cases relaxation of the ligaments is the main feature. There is very generally lengthening of the internal condyle of the femur, and sometimes the entire epiphysis is twisted outward, but the former condition is the most common factor in turning the tibia outward. The tibia itself is sometimes deformed at its upper ex-

tremity, and there may be bowing of the shaft below, forming a compensatory bow-leg. The internal lateral ligament is lengthened, and the external ligament shortened, with similar changes in the inner and outer groups of muscles. Flat-foot is often associated as a cause or as a result of the deformity.

As has been already mentioned, rickets is the most common primary etiological factor. The deformity usually appears when the child begins to walk. In standing in the so-called "attitude of rest" the weight is borne on the external condyles, and in the rachitic child, the bones being preternaturally soft, there are produced an atrophy

Fig. 598.

Genu valgum, or knock-knee.

Fig. 599.

Unilateral knock-knee.

of the external condyle and an increased growth of the internal condyle. At the same time the internal lateral ligament is lengthened by the strain upon it. Adolescent knock-knee develops in patients with relaxed muscular systems whose occupations necessitate much standing and walking. Other rarer causes are flat-foot, infantile paralysis, arthritis, and traumatism.

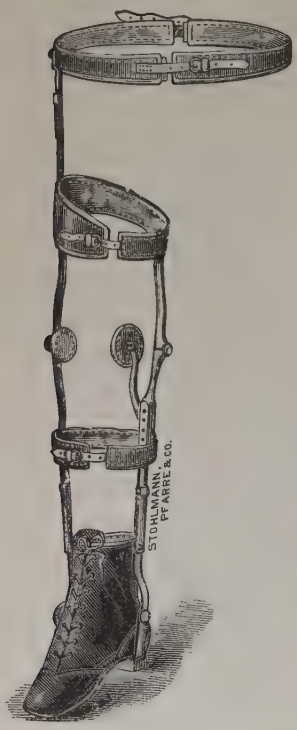
Symptoms.—Besides the unsightly deformity, there may be pain in the knees and a tendency to fatigue upon slight exertion. In unilateral knock-knee with much deformity (Fig. 599) there may be limping, obliquity of the pelvis, and a development of lateral curvature. In double knock-knee the gait is a rolling one. In marked cases of knock-knee we have seen ulcers form over the inner condyles from pressure and friction in walking. When the legs are flexed upon the thighs the deformity largely disappears. This is due to the fact that the condyles are altered in length but not in

thickness, and in this position the tibia articulates with their unaltered posterior surfaces.

Treatment.—In mild cases in very young children the deformity may be outgrown, although this favorable termination is more common in bow-legs than in knock-knee. No matter what course of treatment is decided upon, attention must be paid to the underlying causative condition, which is usually rickets. This includes proper diet, fresh air and sunlight, and the administration of certain drugs, as phosphorus and the phosphates, cod-liver oil, and syrup of iodide of iron. The local treatment may be mechanical or operative. Rubbing of the limbs, and systematic manipulation, bending the knee outward towards the correct position, should be practised daily. In early life, before the stage of eburnation of the bones has been reached—that is, up to about the end of the third year—braces will suffice for correction. They should extend well up the thigh, or even to a band around the waist, and be so adjusted as to make pressure over the inner side of the knee, which joint should be kept fixed. (Fig. 600.) If the bones have become hardened, an operation will be required. *Osteoclasis* and *osteotomy* are the operations usually employed. **Osteoclasis**, or forcible fracture by instrumental devices, is popular in France, but in America is not often employed in knock-knee, on account of the danger of injury to the articulation. **Osteotomy** may be performed upon the femur or the tibia and fibula, commonly on the femur, which is the bone usually at fault. Ogston, Reeves, and Chiene chiselled through the internal condyle to permit its displacement. Macewen's operation, the one most commonly employed, is an osteotomy of the femur, half an inch above the adductor tubercle. (Fig. 601.) The limb should be thoroughly sterilized, and may be rendered bloodless by the application of an Esmarch's bandage. We prefer, however, to omit the use of this, as the small amount of blood which is lost during the operation is a matter of no moment, and the use of hæmostatic apparatus favors consecutive bleeding. The limb is next laid with its outer surface upon a small sand-bag placed under the knee and the lower part of the thigh, and the leg is flexed upon the thigh. A longitudinal incision, about half an inch in length, is made down to the bone, on the inner side of the thigh, an inch above the adductor tubercle; an osteotome is introduced through this incision and carried down to the bone, and is turned so that its cutting surface shall be at a right angle to the axis of the femur; the bone is then divided by driving the osteotome through it by strokes of the mallet, great care being taken, as the posterior surface of the bone is divided, not to injure the large vessels which are in close relation to it. It is usually better not to divide the bone completely with the osteotome, but, when it is about three-fourths cut through, to remove the osteotome and complete the fracture by manual force. After correcting the deformity the wound should be closed by one or two sutures of silk or catgut, and should then be covered with a compress of iodoform gauze, or gauze and iodoform collodion, and a pad of gauze or cotton. A flannel bandage is next applied from the toes to the groin, and, while the limb is held in a slightly over-corrected position, a plaster of Paris bandage is applied from the toes to the groin, and the limb held in this position until the

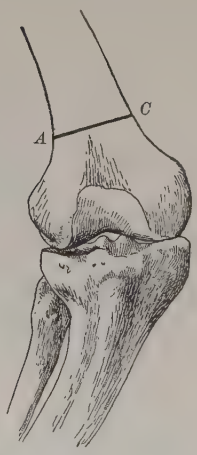
bandage has set. The patient should be kept in bed for a month, and at the end of this time the plaster bandage should be removed and a new one applied, to be worn for another month. At the end of this time the patient may be allowed to begin to use the limbs in locomotion, the knees being supported by light plaster

Fig. 600.



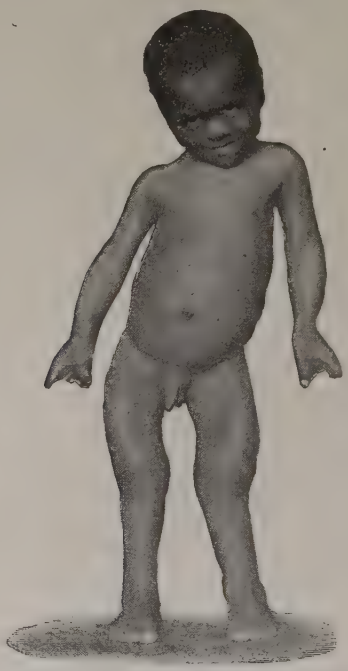
Genu valgum brace.

Fig. 601.



Bone section in Macewen's operation: *AC*, line of section.

Fig. 602.



Result of osteotomy for knock-knee in case shown in Fig. 598.

bandages or braces for a short time. The mortality following this operation is very slight, hemorrhage and sepsis being very rare accidents. The result of osteotomy in the case shown in Fig. 598 is shown in Fig. 602.

BOW-LEGS.

Bow-legs, or genu extrorsum, is the opposite condition to knock-knee. The legs are bowed outward, and the deformity may be single or double, generally the latter. The shafts of the bones usually take the principal part in producing the deformity, the tibia especially being curved outward, and a forward bowing of the same bone may be associated. There is sometimes obliquity also in the articular surface of the femur, with elongation of the external condyle. (Fig. 603.) Like knock-knee, it occurs as a result of the bone-changes in rachitis when the child begins to walk. Its production, according to Bradford and Lovett, is probably due to the position in which the rachitic child stands—that is, with the lumbar spine arched and the thighs flexed. This produces a separation of the knees and a rotation of the femora, bringing the line of gravity inside the knee-joint and causing the

bending of the softened bones outward. Like knock-knee, it may appear before the child begins to walk, and is then due to tonic muscular action.

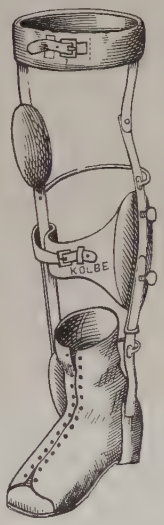
Symptoms.—There is the characteristic deformity, which is associated with a waddling gait, resembling that observed in double congenital dislocation of the hips, although not so well marked. The feet are inverted in walking.

Fig. 603.

Genu extrorsum, or bow-legs.

Treatment.—Expectant treatment is more promising in bow-legs than in knock-knee, as there is a greater tendency to obliteration of the deformity as growth proceeds. This fortunate result is more likely to take place when the curve is a gradual one, involving both femur and tibia. When the tibia is mainly involved, and presents, as is often the case, at its lower end an outward projection, the expectant treatment will be less apt to be followed by disappearance of the deformity. Here also the stage at which the child is first seen has a bearing on the prognosis; as soon as the bones become hard, there is less chance of spontaneous improvement. The hygienic measures described for cases of knock-knee must be carefully carried out. Manipulation involves bending in the inward direction towards a straight line. Mechanical treatment is promising up to the end of the third year. Various appliances are used, aiming at making pressure on the outer side of the knee, or wherever the greatest convexity is situated, with pads for counter-pressure at the inner side of the thigh and ankle. (Fig. 604.) Inversion of the toes must be prevented.

Fig. 604.



Brace for bow-leg.

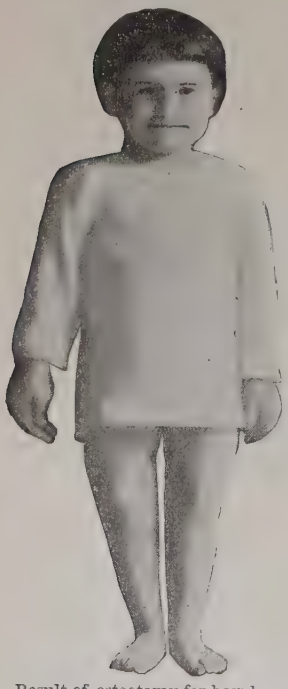
Operative treatment includes both osteoclasis and osteotomy. **Osteoclasis** gives good results where the deformity is due to curvatures of the shafts of the femur and tibia. Rizzoli's or Grattan's instrument may be used, and after correction plaster of Paris is applied.

Linear osteotomy is, however, a preferable operation, as by its employment the correction can be accomplished with greater precision and with less risk of injury to the neighboring articulations. The legs should be thoroughly sterilized, and, if the operator desires, they may be rendered bloodless by an Esmarch bandage; but here, as in the case of osteotomy for knock-knee, we prefer to omit this detail. The limb being supported upon a small sand-bag, a small incision is first made over the fibula at the point of greatest curvature, and the point of the knife is carried down to the bone; a narrow osteotome is slipped down upon this as a guide

until it touches the bone, when the knife is withdrawn and the osteotome is turned at a right angle to the bone; the bone is then divided by a few strokes of the mallet, the osteotome is withdrawn, and the wound is covered with a compress of antiseptic gauze. An incision is next made over the anterior portion of the tibia at the point of greatest curvature, and an osteotome is introduced and turned so that its cutting edge shall be at a right angle to the long axis of the bone, when the tibia is gradually divided by driving the osteotome through the bone by strokes of the mallet. The osteotome may be removed before the posterior shell of the bone is divided, and the separation of the bone completed by manual force. In cases where the deformity is largely confined to the tibia and fibula, division of these bones as described above will be sufficient to correct the deformity; but if the femur is involved in the deformity, osteotomy of this bone may also be required, and should be performed in the same manner.

The dressing of the case after osteotomy consists in closing the small incisions by a few catgut or silk sutures and applying over them a scab of gauze and iodoform collodion or a small compress of iodoform gauze and cotton. A flannel bandage is next applied to the limb from the toes to the groin, and while the limb is held in a position of slight over-correction a plaster of Paris bandage is applied from the toes to the groin, and the limb is held in this position until the bandage has set. This bandage is usually allowed to remain for a month, when it is removed, and a new and lighter one is applied, to be worn for three or four weeks longer; after eight weeks the patient may use the limbs in locomotion without any risk of recurrence of the deformity. (Fig. 605.)

Fig. 605.



Result of osteotomy for bow-legs in case shown in Fig. 603.

If care has been taken as regards asepsis, and no large vessels have been injured in the operation, the patients do well. Occasionally on the second or third day after the operation it will be noticed that the toes are discolored and swollen, in which case the bandages should be removed and the wound inspected, and if no wound-complication is present a new bandage should be applied. If suppuration has occurred in the wound, drainage should be introduced and a new bandage applied, with a fenestra over the wound to permit of its dressing. We have seen serious complications occur after osteotomy for bow-legs in two cases only—secondary hemorrhage from the anterior tibial artery, and osteomyelitis of the tibia—both of which terminated favorably.

ANTERIOR TIBIAL CURVATURES.

In these cases, which occur in subjects of rickets, the most marked anterior curvature is in the lower third of the bone, and this deformity is very

frequently associated with knock-knee and flat-foot. The deformity seems to be largely due to muscular force exerted upon the softened bones by the posterior muscles of the leg. The appearance presented by a well-marked case of anterior tibial curvature is shown in Fig. 606.

Treatment.—The treatment in this condition consists in a cuneiform osteotomy of the tibia and fibula at the point of greatest curvature, with subcutaneous division of the tendo Achillis and fixation of the limb in the corrected position by a plaster of Paris bandage. In mild cases linear osteotomy may correct the deformity satisfactorily, but in cases of marked deformity it will be found necessary to perform a cuneiform osteotomy of

FIG. 606.

Anterior tibial curvature.

FIG. 607.

Result of cuneiform osteotomy for anterior tibial curvature.

the tibia and a simple section of the fibula and to divide the tendo Achillis before the deformity can be corrected. In performing cuneiform osteotomy in these cases the bones are exposed by turning up a flap or by a transverse incision, when a wedge of bone of sufficient size is removed by a chisel from the tibia, and the fibula is divided; the tendo Achillis is next divided, and, after closing the wounds and applying a gauze dressing, the leg is held in the corrected position and a plaster of Paris bandage is applied; fenestræ may be cut over the wounds if subsequent dressing is required. The result of a cuneiform osteotomy for anterior tibial curvature is shown in Fig. 607.

GENU RECURVATUM.

This is a deformity in which the knee is hyperextended upon the thigh, presenting a prominence behind the joint. (Fig. 608.) The condition may be slightly developed, or may be so marked as to constitute a serious deformity and prevent flexion of the leg upon the thigh. It seems to be due to stretching and relaxation of the posterior ligaments of the knee, with marked contraction of the anterior portion of the capsular and lateral ligaments of the joint.

Treatment.—As soon as the deformity is noticed in an infant, systematic manipulation should be practised by bending the knee in the proper direction, and this method of treatment if continued for some time may be followed by marked improvement in the position and motion of the joint. In cases coming under the care of the surgeon when the deformity has been untreated, repeated manipulations under anæsthesia and fixation with plaster of Paris may be practised with improvement in the condition. Subcutaneous division of the anterior portion of the capsule of the joint and of the lateral ligaments has been employed, and in cases which resist these methods of treatment, excision of the joint with the view of correcting the deformity and securing bony ankylosis in good functional position would seem a justifiable procedure.

Fig. 608.

Genu recurvatum. (After Treves.)

ANKYLOSIS.

Bony Ankylosis of the Knee.—This deformity usually results from tubercular ostitis of the knee or from wounds involving the knee-joint, followed by suppurative arthritis; bony ankylosis being apt to occur in any of these affections when the articular cartilages have been destroyed.

Bony ankylosis of the knee with little deformity calls for no operative treatment, as a patient presenting this condition can usually have good use of the limb by wearing a high shoe to compensate for the shortening. When, however, the knee is ankylosed and marked angular deformity is present, as shown in Fig. 609, operative treatment is required to give the patient a useful limb.

Treatment.—This deformity may be corrected by turning up a flap from the anterior surface of the knee and removing a wedge-shaped section of bone with a saw or a chisel, including the patella and a portion of the head of the tibia and condyles of the femur, the base of the wedge corresponding to the anterior surface of the knee. In removing the apex of the wedge great care should be taken to avoid injury of the popliteal vessels. After a sufficient amount of bone has been removed to permit of the limb being brought into a straight position, fixation of the surfaces of the bone may be secured by wire sutures or nails. The flap is replaced, the wound is closed by sutures and covered with a gauze dressing, and the limb from the toes to the groin is fixed by a plaster of Paris dressing, which should be retained for a month and then replaced by a fresh one. Fixation should be maintained for some months even after union seems firm, otherwise there will be a tendency to recurrence of the deformity. In less aggravated cases of this deformity the correction may be accomplished by osteotomy, a section being made through the condyles of the femur and another through the head of the tibia, which allows the limb to be brought into the straight position. The limb should then be fixed by a plaster of Paris bandage, and fixation maintained for some months.

Ankylosis of the Hip with Flexion after Hip-Disease.—In many cases of tuberculosis of the hip-joint which terminate in recovery, owing to destruction of the joint or change in the shape of the head and neck of the bone, flexion of the thigh upon the pelvis occurs, and a permanent bony or firm fibrous ankylosis of the joint results, with the limb in such a position that the patient is able only to bring the toes of the extended foot

FIG. 609.

Ankylosis of the knee.

FIG. 610.

Ankylosis of the hip following coxalgia.

in contact with the ground. (Fig. 610.) This deformity usually follows tubercular disease of the hip which has not been carefully treated. It is observed in cases which have been complicated by abscess, as well as in those in which this complication has not occurred.

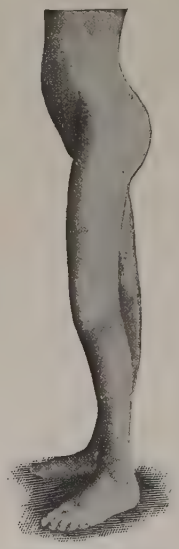
Treatment.—When the deformity results from fibrous ankylosis, subcutaneous division of the contracted muscles and fascia, with subsequent extension, is often followed by its correction. In cases, however, in which very firm fibrous or bony ankylosis exists, an osteotomy, according to the method of Adams or Gant, an operation attended with little risk, will be required to correct the deformity. Adams's operation, which consists in a subcutaneous section of the neck of the bone, is made with a short narrow saw. Gant's modification of this operation consists in making a section of the femur just below the lesser trochanter, the bone being divided with a saw or an osteotome. In correcting this deformity when it is the result of hip-disease, we prefer Gant's operation to that of Adams, as the head and neck of the bone are often very much changed in shape, and the section is necessarily made through diseased tissue in the latter situation. Moreover, if only fibrous ankylosis exists, recurrence of the deformity may take place after section of the neck of the bone by the action of the muscles inserted into the lesser trochanter. In Gant's operation, or *subtrochanteric osteotomy*,

the section is made through the femur just below the lesser trochanter in healthy bone, and if the upper fragment is flexed by the muscles inserted into the lesser trochanter the lower fragment unites at an angle, and subsequent flexion of the thigh will be impossible. The appearance of the femur after a subtrochanteric osteotomy is shown in Fig. 611. In performing subtrochanteric osteotomy a saw or an osteotome may be used. The limb being sterilized, an incision is made with a long, sharp-pointed tenotome on the outer side of the thigh just below the position of the lesser trochanter, and is carried down to the bone; an Adams's saw is next introduced upon the tenotome as a guide, and when the bone has been reached the tenotome is withdrawn and the blade of the saw is gradually worked over the upper surface of the bone: as there is often adduction of the thigh as well as flexion, care should be taken to make the section at right angles to the long axis of the bone. The bone is then divided with short strokes of the saw from above downward, and when it is nearly divided the saw may be withdrawn, the division being completed by fracturing the remaining portion of the bone by bending the thigh downward. The wound should be closed with a compress of iodoform gauze or gauze and iodoform collodion, and the limb brought into a straight position and slightly abducted. The after-treatment consists in the application of a plaster of Paris bandage to the leg, thigh, and pelvis to fix the parts, or the case may be treated by an extension apparatus, weight and pulley, lateral support at the same time being given to the limb by sand bags. Fixation or extension should be maintained for at least six or eight weeks, after which the patient should use crutches for a few weeks before he is allowed to bear his weight upon the limb in walking. The results following this operation are very satisfactory, and the operation is one attended with little danger. The correction of the deformity in Fig. 610 by osteotomy is shown in Fig. 612.

Fig. 611.

Femur after subtrochanteric osteotomy.

Fig. 612.



Result of subtrochanteric osteotomy for deformity following coxalgia.

CONGENITAL DISLOCATION OF THE HIP.

Congenital dislocation of the hip is a rather infrequent condition, although the most common of the congenital dislocations. It is more frequent in females than in males, and may be single or double. A number of theories have been advanced as to its causation, the most probable being that which

ascribes it to an arrest of development of the rim of the acetabulum. According to Lorenz, certain subluxations due to mechanical causes in connection with the cartilaginous and perhaps rachitic structures may become complete luxations through exertion and muscular action. It is sometimes hereditary. Before walking, the acetabulum is shallow and undeveloped, and the head of the femur may occupy any of the positions noted in traumatic dislocations, but most commonly it lies on the dorsum ilii. After walking the head becomes deformed and flattened, and forms a new cavity for itself over the ilium, the original acetabulum filling up with exostoses. The capsule becomes thickened and relaxed, and the round ligament sometimes disappears. The gait is characteristic in double cases, being a duck-like waddle. There is lumbar lordosis, with great prominence of the abdomen, and tilting of the pelvis; the lower extremities are short. (Fig. 613.) In unilateral cases there are much limping, shortening of one leg, lateral curvature of the spine, and flexion and tilting of the pelvis.

Fig. 613.

Double congenital dislocation of the hip.

The condition must be diagnosed from infantile paralysis, bow-legs, hip-disease, and traumatic dislocations. The history, appearance, position of the trochanters, laxity of joint structures, and absence of pain are the important diagnostic points. The prognosis, aside from treatment, is bad, natural cure never occurring, and much disability often resulting.

Treatment.—Mechanical measures aimed at accomplishing and maintaining reduction have often been tried. They include continuous extension for a long time, and the plaster of Paris dressing, but are rarely curative. Pelvic belts and corsets sometimes afford relief by fixing the pelvis and supporting the trochanters. Various operative procedures, as subcutaneous tenotomy, excision, and chiselling out the acetabulum, have been practised. Hoffa and Lorenz have done the most valuable work in this direction, and the operation of Lorenz, which has been practised by that surgeon in a large number of cases with good results, is the best yet devised. He draws down the head of the bone by extension, sometimes doing a tenotomy of the adductors, and makes an incision between the tensor vaginæ femoris and the gluteus medius down to the capsule, which he opens by a T-shaped incision. The head and neck of the femur are shaped, if necessary, and the acetabulum is chiselled out, the reduction being then accomplished. The capsule and ligaments should be spared as far as possible. The wound is dressed, and the leg firmly fixed in a position of slight abduction with a plaster of Paris dressing. Up to the age of six years an attempt may be made to replace the head in the acetabulum by manipulation. To accomplish this Lorenz recommends

reduction by extension, followed by flexion, abduction, and outward rotation, under anæsthesia, with fixation in the abducted position for three months, after which locomotion is allowed, abduction being gradually lessened.

Congenital dislocations other than of the hip are very rare, and are often associated with other marked defects of development, as acrania, spina bifida, etc. Among other rare congenital malformations are absence of the upper and lower extremities, and partial or complete absence of the humerus, femur, tibia, and fibula.

Club-hand is also a rare affection, and may be congenital or acquired. The congenital variety consists usually in a flexion (rarely an extension) of the hand on the forearm, often in combination with an inclination towards the radial or the ulnar side. There may be partial or complete absence of the radius, and there are sometimes associated malformations of the fingers. Acquired club-hand may follow injuries to nerves or other forms of paralysis, the contraction of cicatrices, and injuries of the bones. When the epiphysis of the radius or of the ulna is destroyed by disease or injury, the growth of the other bone forces the hand into an unnatural position.

Treatment.—In mild cases manipulations and tenotomies are of benefit. In those following epiphyseal inflammation the excision of a sufficient portion of the uninjured bone to permit of straightening is indicated. Amputation may be called for if the limb is absolutely useless.

Fig. 614.

Supernumerary thumb. (Agnew.)

Deformities of the Fingers.—These comprise supernumerary digits, or a deficiency in their number, and congenital or cicatricial webbing of the fingers.

Supernumerary digits are usually situated on the ulnar side of the hand, but are also observed upon the radial side. (Fig. 614.) They may be perfectly formed, even to the presence of a distinct metacarpal bone, or may spring from another finger, sometimes being attached only by a very slender pedicle. Amputation is indicated if they are unsightly or useless, and should be performed in early life.

Webbed Fingers.—Syndactylism consists in a union of two or more, sometimes all, of the digits in a part or in their entire length, and is often associated with a lack of development. The union may be by skin, muscle, and fibrous tissue, or the bones may be fused. (Figs. 615, 616.) In complete webbing the hand is often shortened, and there are restricted movements of the fingers.

Treatment.—Several operations have been devised for the relief of this deformity, their object being to bring flaps of sound skin to the opposing sides of the fingers, and to secure rapid healing at the bottom of the cleft, as granulation starting here is liable to lead to recurrence of the condition by the formation of a cicatricial web. Didot's method, as shown in the diagram (Fig. 617), consists in turning back a palmar and a dorsal flap from opposite fingers, and, after dividing the rest of the web, bringing them

round and stitching them in place. Zeller's and Agnew's operations are done by turning back a triangular flap of skin from the dorsum of the web, its base downward corresponding to the bases of the fingers, and, after di-

Fig. 615.

Webbed fingers.

Fig. 616.

Webbed fingers.

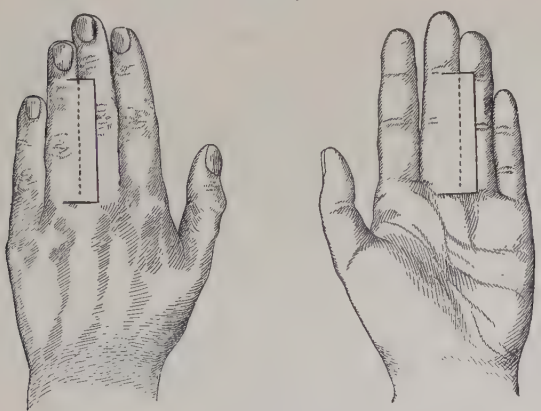
viding the rest of the web, turning it forward into the interdigital cleft, thus securing a bridge of skin between the fingers.

Dupuytren's finger contraction is a flexion of the finger due to contraction of the palmar fascia, which, being inserted into the proximal phalanx, when shortened draws the digit down into the palm. (Fig. 618.) The ring and little fingers are most commonly the subjects of this deformity. As causes may be mentioned gout and rheumatism, a personal or family history of which is often obtainable,

Fig. 618.

Dupuytren's finger contraction.

Fig. 617.



Didot's operation for webbed fingers.

the constant pressure of instruments on the palm, and, according to some, reflex nervous irritation excited by traumatism. Neuralgic pains in the arm

are sometimes present. Cases have been recorded of syphilitic origin (Ricord and Richet) which were cured by the administration of iodide of potassium. Dupuytren's contraction must be separated from contractures due to shortening of the flexor tendons, from cicatrices, and those due to joint disease.

Treatment.—The treatment consists in a division of the contracted bands by subcutaneous tenotomy, as advised by Adams. The tenotome is introduced beneath the skin, and the fascia is divided by cutting downward; it is generally necessary to introduce the knife at several points, owing to the adhesions between the fascia and the skin. The after-treatment consists in the use of a splint for three weeks. When the open method is practised, a V-shaped flap of skin is turned up, and a number of transverse incisions of the contracted bands are made, or the contracted bands may be completely removed.

Contractures of Joints.—These may result from diseases of the joints of the upper and lower extremities, or may follow paralysis, either of cerebral origin, as the cerebral spastic palsies, or of spinal origin, as acute anterior poliomyelitis. The measures taken to overcome deformities resulting from joint disease are considered under Excisions. For the spastic contractures, manipulation and massage, electricity, and muscular exercise should be directed, and, finally, tenotomy may be useful. Mechanical treatment is unsatisfactory, as the contractures return after the removal of the apparatus. After an attack of acute infantile paralysis an apparatus is very useful in the prevention of contractures, and should be employed as a support for the body and to hold the limb in proper position in walking. If there is a tendency to flexion or over-extension of the knee, a brace with a lock-joint at the knee should be worn; and, similarly, if there is extensor paralysis of the foot, it should be kept at a right angle, to prevent the occurrence of talipes equinus, or, what is more usual, equino-varus or equino-valgus. If these measures are neglected, severe contractures, subluxations, and even dislocations (especially of the hip) are likely to occur. In addition, electricity and massage should be employed. If deformities are present when the case comes under observation, mechanical appliances are still useful for correction, and, in addition, tenotomy, myotomy, shortening of tendons, or forcible straightening may be practised. The superficial and deep flexor muscles of the hip, the adductors and rotators, may require division, the open incision being preferable where the deeper muscles are to be attacked. The hamstring tendons in flexion of the knee are usually accessible for subcutaneous tenotomy, the knife being introduced so as to cut from the middle of the popliteal space outward, especial care being necessary in dividing the tendon of the biceps femoris to avoid wounding the external popliteal nerve, which runs close to its inner border. Similarly, at the ankle, the tibialis anticus, tibialis posticus, peroneals, etc., may be attacked subcutaneously. Tendons are best shortened by the method of Walsham and Willet, whereby the tendon is slit obliquely and the ends slid past each other until the desired shortening is obtained.

Arthrodesis, or excision of a joint, as a means of securing a stiff joint in place of a flail-like one, has been recommended, and osteotomy may be called for to overcome the knock-knee which sometimes follows palsies.

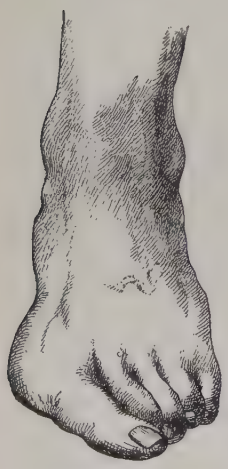
Hammer-Toe.—This is a not uncommon affection, in which the proximal phalangeal joint of the toe is permanently flexed and the distal joint is hyper-extended, the deformity being caused by shortening of the lower fibres of the lateral ligaments. The second toe is the one most commonly affected (Fig. 619), although other toes may be involved; the affection may also be symmetrical. The deformity is commonly seen in children and young adults, and probably arises from unusual length of the affected toe, whose extremity is pressed backward by the boot, and gives rise to permanent flexion and hyper-extension as above described. The deformity is very marked, and causes great pain and discomfort, as corns are apt to form on the extremity of the toe and upon the summit of the projection.

Fig. 619.

Hammer-toe.

Treatment.—Subcutaneous section of the contracted tissues is usually followed by temporary relief only, and the deformity soon recurs: so that the radical treatment consists in amputation of the toe at the metatarso-phalangeal joint or in excision of the proximal phalangeal joint. Amputation is often practised with good results, but in the case of the second toe may be followed by the development of hallux valgus from want of lateral support to the great toe, so that in this toe excision should be preferred. In excising the joint enough bone should be removed to allow the toe to be brought into a straight position. The wound should be dressed with a gauze dressing, and a narrow strip of binders' board incorporated in the dressing to keep the toe in a straight position, and worn until union of the bones has occurred, which usually takes place in two or three weeks. A somewhat similar condition in the great toe, known as **hallux flexus**, is occasionally seen. The *treatment* of this condition consists in manipulation and the use of properly fitting shoes, and if this is not followed by improvement, the head of the proximal phalanx, or the head of the metatarsal bone, should be excised, which will usually correct the deformity.

Fig. 620.



Hallux valgus.

Hallux Valgus.—This deformity consists in abduction of the great toe at the metatarso-phalangeal joint, with marked enlargement of the head of the first metatarsal bone by osteophytic growths, caused by a chronic osteo-arthritis. (Fig. 620.) The distal phalanx may rest upon or pass under the second toe, and a bursa or bunion is usually present between the skin and the bone, which becomes inflamed from pressure of the shoe and causes great pain and disability. **Treatment.**—When the deformity is slight, the wearing of properly shaped shoes may prevent the subsequent development of the condition to one of marked deformity or discomfort. The use of a properly fitting splint may also be followed by good results. In severe cases the best results are obtained by excision of the head of the metatarsal bone and of any bony outgrowths

which are present, and the toe should afterwards be fixed in a position of adduction. We have seen very satisfactory correction of this deformity by osteotomy of the metatarsal bone above its head: after relieving the deformity the correction should be maintained for some weeks by a plaster of Paris bandage. *Fowler's* operation consists in making an incision in the web and on the dorsum between the toes, followed by division of the external lateral ligament, and dislocation of the toe inward, opening the joint; the internal condyle of the metatarsal bone is next removed, the toe replaced, and the wound closed with sutures, the resulting scar being out of the way of pressure. It is not to be employed when suppuration has commenced in the bursa or joint.

TALIPES, OR CLUB-FOOT.

Talipes, or club-foot, is a deformity in which the relations of the different parts of the foot to one another, and of the foot to the leg, are altered from the normal. It may be either congenital or acquired, and embraces the following primary forms. *Talipes equinus* is the condition in which the foot is extended, the weight being borne on the balls of the toes. *Talipes calcaneus* is the reverse condition, the toes being drawn up and the heel in contact with the ground. *Talipes varus* consists in an inversion of the foot; the inner side is drawn upward, and the patient walks on the outer edge of the foot. *Talipes valgus* is the opposite of varus, the foot being everted. Alterations in the arch include two varieties—*talipes cavus*, in which the arch is increased, the anterior portion of the foot being flexed on the posterior, accompanied by the presence of a furrow across the sole, and *talipes planus*, in which the arch is broken down. These different primary forms are very frequently combined, the name indicating the deformity, as equino-varus, equino-valgus, calcaneo-valgus, and calcaneo-varus, the combinations producing compound deformities with flexion and eversion, flexion and inversion, etc. Club-foot is a frequent deformity: of the two forms, acquired and congenital, the former is encountered the more frequently, the proportion being about three to two, according to Adams. Congenital club-foot is more common in male than in female infants, and is oftener double than single. The etiology is not yet well made out. It is undoubtedly inherited in some cases, and consanguinity in the parents is well established as a favoring factor. It has been regarded as a result of retarded development, ascribed to a failure of rotation from the primary intra-uterine position, in which the soles are turned inward, and to prenatal lesions of the nervous system. The acquired forms are generally paralytic in origin, especially as sequelæ of acute anterior poliomyelitis, resulting in equinus, equino-varus, and equino-valgus, calcaneus and valgus being rarer. Pure equinus is excessively rare as a congenital type. *Hysterical club-foot* has been observed in young neurotic females. Other rare cases are the results of sprains, fractures, and ostitis of the ankle. It may also occur as a sequel of knock-knee.

Pathology.—The skin, tendons, fasciæ, and bones all take part in the deformity. The soft tissues are lengthened or shortened, as the case may be, the tendons are misplaced, and the bones are altered in shape and brought into new relations with one another.

Treatment.—Treatment may be divided into mechanical and operative. Mechanical treatment by the use of apparatus necessitates also manipulation and massage, and sometimes electricity can be used with advantage. Operative treatment comprises forcible correction (*brisement forcé*), tenotomy, Phelps's operation (open incision), and the various bone operations. Manipulation should be instituted from the first in congenital cases, and practised daily, the foot being pressed into the natural position and held there while massage is applied to the contracted muscles. This must be combined with the use of a suitable shoe for retention, and will sometimes alone effect a cure. Under anæsthesia the foot can be at once over-corrected, and then can be held in that position by plaster of Paris renewed from time to time. Apparatus is designed to assist in correction, and to retain the foot in position after it has been brought into the normal position by other measures. Apparatus employed to correct the deformity depends on the application of force by elastic traction, leverage, and screw power, the appliances most widely employed being the shoes of Scarpa and Knapp, Taylor's shoe, Shaffer's modification of the same, and the elastic traction appliances of Barwell and Sayre, the latter being especially applicable to paralytic cases. As retentive apparatus, the simple plaster of Paris is very useful by itself, or when employed to hold in position felt, steel, or other materials used for support.

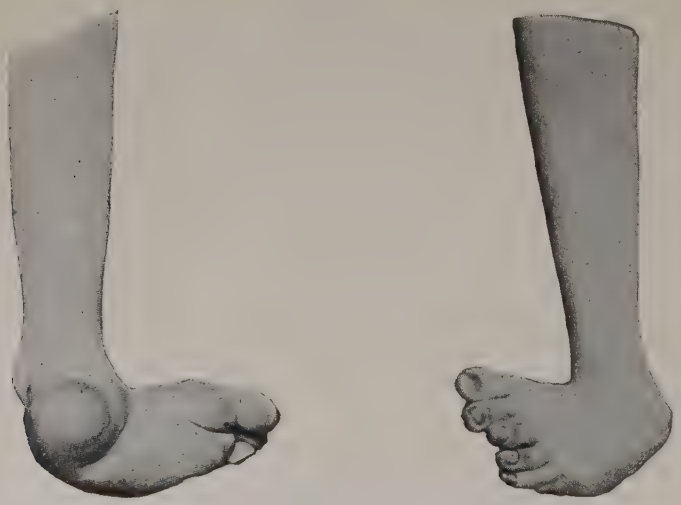
Tenotomy.—In the severer grades of club-foot, and as an adjunct to mechanical treatment, tenotomy is of great usefulness, from the ease with which it can be performed and the amount of time saved, the foot being immediately straightened, although the importance of the subsequent treatment, carefully and continuously carried on, must never be overlooked. Subcutaneous tenotomy, or open incision of the tendons, may be employed. Tendons may also be lengthened by oblique incision or by splitting them and applying sutures. (See page 415.) Several forms of tenotomes are employed, a sharp-pointed one being often used to pierce the skin, after which a blunt-pointed knife is introduced flatwise beneath the tendon, and the section made from below upward by a to-and-fro rocking motion, the foot being held so as to render the tendon tense until it is felt to give way, when the foot is released, the knife withdrawn, and the wound washed and covered with a piece of gauze. The foot is forcibly over-corrected and put up immediately in plaster of Paris. If a vessel be wounded, which is an uncommon accident if ordinary care be exercised, the bleeding can generally be easily controlled by a compress. Authors differ as to the time at which tenotomy should be resorted to in congenital cases, some practising it as early as the second or third month, while others, who lay more stress upon manipulation and mechanical measures, do not recommend it before the child is ten months or a year old. We are in favor of the latter method of treatment. After tenotomy a retention walking-shoe will be required, and after repair is complete a continuance of the daily manipulation and massage.

Brisement forcé, or forcible correction under ether, is practised, aided by instruments capable of exerting great force, as the devices of Gibney, Morton, Bradford, and Phelps. The bone operations employed in the correction of club-foot, which are required only in old and neglected cases after milder

methods have proved ineffectual, are numerous. *Excision of the astragalus* and *tarsectomy*, or excision of a wedge-shaped portion from the outer side of the tarsus, are the most important. Excision of the astragalus yields excellent results. It has the disadvantage of shortening the limb, but does not impair the form of the foot or the stability of the arch as much as does resection of the tarsus.

Talipes Equino-Varus.—This is the most common congenital form of club-foot, constituting about three-fourths of the congenital cases. It generally affects both feet, but may be confined to one foot. The deformity consists in an elevation of the inner border of the foot, the sole being turned

FIG. 621.



Equino-varus, posterior and anterior view.

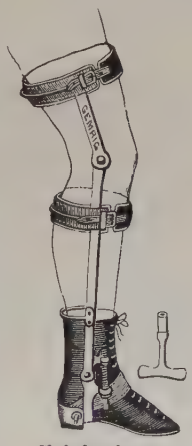
towards the median line of the body, the heel being more or less drawn up, and the distal portion of the foot being flexed upon the proximal at the medio-tarsal articulation. (Fig. 621.) In equino-varus the astragalus is tilted forward, and the head and neck of this bone are deflected inward, the scaphoid articulating with the inner side of the head, or even in some cases with the inner malleolus, and the os calcis and cuboid are altered in shape. When the child begins to walk, these changes are all exaggerated, and the deformity increases. The muscles of the legs become atrophied, and callosities and bursæ form over the points of pressure, which often become inflamed and cause great pain and disability. There is great impairment of the gait in severe cases, the feet being lifted one over the other in walking.

Treatment.—In congenital cases of equino-varus much can be done to correct the deformity by *manipulation* and systematic straightening of the feet. An intelligent mother or nurse, by persistent manipulation under the direction of the surgeon, is often able to bring the parts into such a position that the deformity will be largely corrected by the time the patient is able to walk, and with the aid of a brace or a walking-shoe the patient will get on very well, and operative treatment may not be required. Another method of treatment consists in the use of the plaster of Paris bandage applied after

the position of the foot has been corrected by the use of some force, the bandage being removed at intervals of two or three weeks, when, the correction being increased, a fresh plaster bandage should be applied. These procedures are repeated until the child is able to walk, when a brace is applied to maintain the correction and to allow the child to exercise the physiological function of the foot, which in itself tends to prevent the recurrence of the deformity.

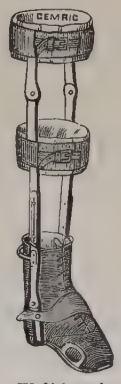
Tenotomy may also be employed to correct the deformity; but, as a rule, when it is possible, we prefer to employ the methods of treatment previously described until the patient is able to walk, and seldom resort to tenotomy in patients under one year. The subcutaneous division of the anterior and posterior tibial tendons, the tendo Achillis, and the plantar fascia will generally correct the deformity, and after the foot has been brought into good position it should be put up in a plaster of Paris dressing, which should be worn for a few weeks; when this is removed a brace is applied, and the patient is encouraged to walk. (Fig. 622.) In relapsing cases, or in old cases in which no treatment has been used, the deformity may be corrected by Phelps's operation, by excision of the astragalus, or by a cuneiform osteotomy.

Fig. 622.



Club-foot brace.

Fig. 623.



Walking-shoe for use after operation for club-foot.

Open incision, or Phelps's operation, consists in making an incision, with full aseptic precautions, on the inner side of the foot, beginning directly in front of the inner malleolus, and carrying it down to the inner side of the neck of the astragalus. All the shortened muscles and tendons are divided, as well as the plantar fascia and the deltoid ligament. After straightening the foot, the wound is allowed to fill with blood-clot and is covered with a gauze dressing; a plaster of Paris dressing is then applied, to be retained until the wound has healed.

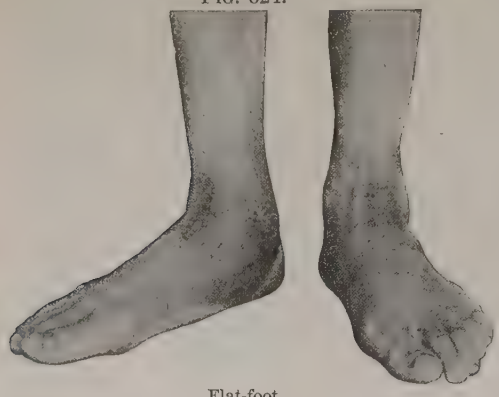
Excision of the astragalus is in our judgment the most satisfactory method of correcting the deformity in inveterate and relapsing cases. The astragalus is exposed by an incision upon the outer side of the foot, and after it has been disarticulated any tendons or fascia which resist the correction of the deformity are divided subcutaneously; the wound is closed, a gauze dressing is applied, and the foot is held in the corrected position by a plaster of Paris dressing. We have seen most satisfactory correction of the deformity and excellent functional results follow this operation.

Tarsectomy, which consists in removing a wedge-shaped section of the tarsal bones from the external surface of the foot, has also been employed. Although we have seen excellent results following this operation, we do not think they compare, as a rule, with those following excision of the astragalus.

After the deformity has been corrected by any of these operations, a properly fitting brace, by which extension and eversion of the foot can be maintained, should be worn for some time. (Fig. 623.)

Talipes Valgus, or Flat-Foot.—This deformity is usually non-congenital, and consists in eversion of the foot, with flattening or disappearance of the arch. There is abduction of the anterior part of the foot, and more or less elevation of the outer border of the foot from yielding of the arch. (Fig. 624.) The tarsal bones, especially the astragalus and scaphoid, are altered in their relations, but are not much changed in shape. There is relaxation in the extensors, especially in the peroneus longus, as well as in the plantar muscles and ligaments. Talipes valgus is usually seen in feebly developed children, and results from the body weight coming upon a foot which is unable to sustain it. It is also often seen in adults, constituting *talipes adolescentium*, which is most common after puberty and is due to the flattening of a relaxed arch under the increased body weight. This deformity may also be due to rickets, knock-knee, sprains, and badly united fractures of the bone of the leg in the region of the ankle-joint.

Fig. 624.



Flat-foot.

Symptoms.—In talipes valgus the patient stands with the knees flexed and with the feet everted, and in walking the gait is heavy and uncertain. Pain is a common symptom, and is referred to the astragalo-scaphoid articulation (*tarsalgia*), the inner malleolus, and the ball of the great toe. This form of talipes is often overlooked, the severe pain which accompanies the condition often being referred to sprains, rheumatism, or ostitis; but a careful examination will show the deformity and the altered gait.

Treatment.—Congenital valgus may be treated by gradual reposition of the parts, massage, and bandaging, and later by the application of apparatus supporting the arch of the foot. In the acquired form, where there is weakness of the extensors, much benefit may be gained by exercise of the foot, the patient practising raising himself a number of times daily on tiptoes, and by the application of massage and electricity to the weakened muscles. In addition, the use of a metal plantar spring worn in the shoe which supports the arch is of great value. (Fig. 625.) In cases in which there is much eversion of the foot the use of a steel ankle-brace is often required, and in very marked cases it may be necessary to restore the position of the arch under ether before the plantar spring or brace can be used. Tenotomy or tarsectomy is rarely required in this deformity.

Talipes Calcaneus.—This deformity may be congenital or acquired, and most frequently results from infantile paralysis. In this condition the patient walks upon the heel, with the anterior portion of the foot raised,

and there is usually some abduction of the foot. (Fig. 626.) **Treatment.**—This condition can often be relieved by manipulation and bandaging, or by the use of a shoe with an extension sole and a brace. In severe cases, or those which have resisted other forms of treatment, the deformity may be corrected by resecting a portion of the tendo Achillis, suturing the ends

Fig. 625.

Plantar spring for flat-foot.

Fig. 626.

Talipes calcaneus.

together, and fixing the foot in the corrected position by a plaster of Paris bandage. After repair of the divided tendon has taken place the patient should wear for some time a shoe and brace to prevent recurrence of the deformity.

Pes Cavus.—This deformity consists in marked exaggeration of the arch of the foot. It may be either congenital or acquired, but the latter form is most common. It may result from contraction of the tibialis anticus and peroneus longus muscles and of the plantar fascia, and may also result from paralysis of the gastrocnemius and soleus muscles. In this affection the dorsum of the foot is prominent, and in walking the patient bears his weight upon the heel and the balls of the great and little toes. (Fig. 627.) **Treatment.**—This consists in the use of a shoe with a steel plate, and in severe cases the free division of the plantar fascia and subcutaneous section of the contracted tendons may be required. After the deformity has been corrected by operative treatment the foot should be fixed in the corrected position by a plaster of Paris bandage, and subsequently a walking-shoe or a brace should be worn to prevent relapse.

Talipes Equinus.—This deformity consists in an elevation of the heel, which may be so slight as merely to prevent the foot from being fully flexed beyond a right angle, or so marked as to compel the patient to walk upon the balls of the toes and the metatarsal bones. (Fig. 628.) Talipes equinus is rare as a congenital but common as an acquired affection, and results from infantile paralysis, spastic paralysis, and post-hemiplegic contractures; contraction of the superficial extensor muscles and relaxation or paralysis of the flexor muscles of the leg are the essential factors in its production. The deformity in severe cases is very marked; the head of the astragalus projects upon the dorsum of the foot above the astragalo-scaphoid joint, and the scaphoid is subluxated. Contraction of the plantar ligaments and fascia is also well marked.

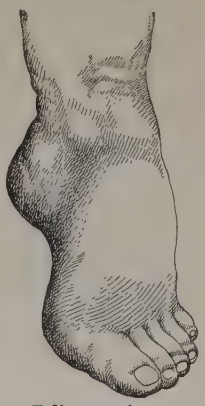
Treatment.—If the deformity is moderately developed, manipulation and the use of a shoe and brace with an extension sole may serve to correct it. In severe cases, however, subcutaneous division of the tendo Achillis and plantar fascia may be required before the deformity can be satisfactorily

corrected. The division of the plantar fascia should be first done, and subsequently the tendo Achillis should be divided. After section of these

Fig. 627.

Pes cavus.

Fig. 628.



Talipes equinus.

structures the deformity should be corrected, and a plaster of Paris bandage worn for a few weeks; after this a shoe with an extension sole applied.

Metatarsalgia.—Metatarsalgia is a neuralgic affection of the foot, which has been described by T. G. Morton, the pain radiating from the head of the fourth metatarsal bone. In this condition there is marked tenderness upon pressure, but there are no signs of inflammation. It is supposed to be due to crowding together of the heads of the metatarsal bones when lateral pressure is made, filaments of the plantar digital nerves being pressed upon. (Fig. 629.) Ill-fitting shoes seem to play an important part in its development. **Treatment.**—This consists in the application of a flannel roller over the ball of the foot, or the use of circular strapping to prevent the foot from flattening, and the wearing of broad, properly fitting shoes. In severe cases the only treatment which gives permanent relief is excision of the metatarso-phalangeal articulation of the fourth toe, or amputation of this toe, with removal of the head of the fourth metatarsal bone.

Fig. 629.

Skiagraph of the feet in a case of metatarsalgia of the left foot. (Dr. J. M. Stern.)

Tarsalgia.—Tarsalgia is a neuralgic affection of the tarsus which occurs in those who are compelled to stand or walk constantly, and is probably due to relaxation of the ligaments; it is frequently associated with flat-foot. **Treatment.**—This consists in the wearing in the shoe of a metal plantar spring to support the arch of the foot, or a light brace attached to the shoe, which prevents lateral movements of the tarsus.

CHAPTER XXIV.

SURGERY OF THE HEAD.

THE SCALP.

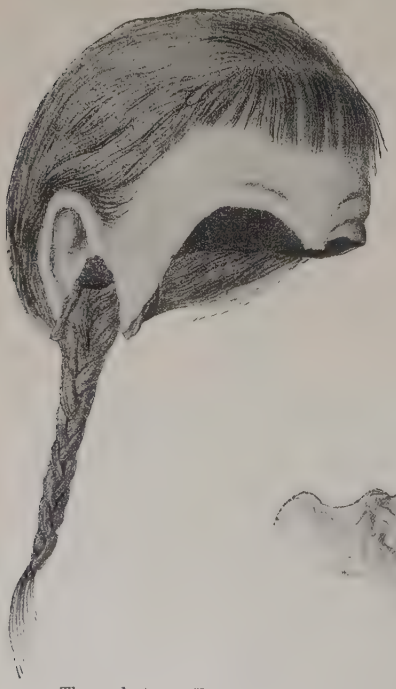
Injuries.—While the scalp is naturally protected from injury by the hair, it is much exposed to certain lesions on account of its situation upon the vertex and the hard skull beneath it. **Contusions** of the scalp are marked by the amount of effused blood and serum which collects in the loose connective tissue under the skin, and causes great swelling, sometimes an inch or more in thickness. On account of the underlying curved surface of bone, blows on the scalp with blunt bodies often produce rather sharp-cut wounds instead of contusions, the edges of which may, however, be so much contused as to be liable to gangrene. If the force is applied at a tangent to the skull, the soft parts may be detached, forming undermined pockets or large ragged flaps. **Incised wounds** of the scalp are not very common, and do not differ from those in other situations except that the hemorrhage is profuse and may even be fatal. The arrest of the hemorrhage may be difficult, because the forceps do not hold well in the tough scalp, and it may be necessary to grasp its entire thickness with them. Ligatures are apt to slip off, but fortunately are seldom needed, as compression will answer. If the bleeding is very difficult to control, a suture should be passed through the scalp around the divided vessel. **Hæmatoma** of the scalp from contusions is peculiar in that it is surrounded by a hard œdematous zone and the blood coagulates first at the edges, leaving a soft centre which may persist for some time and may closely resemble a depressed fracture of the skull. If the blood is effused between the pericranium and the skull, a ring of fibrous tissue, or even of new bone, may form, and remain permanently at the site of the injury. This is most often seen in the newly born infant as the result of the *caput succedaneum*. If a large vessel be injured, a pulsating hæmatoma may be formed, which requires an incision with ligature of the bleeding vessel lest an aneurism form later.

Treatment.—The treatment of these injuries is the same as elsewhere, *contusions* being best treated by cold and astringent applications, and an ice-bag will often answer. Massage may be useful to promote absorption of the œdema and the blood-clot. A hæmatoma may suppurate and form an abscess requiring incision, and in cases of very large and persistent hæmatomata it may be necessary to drain away the blood by aspiration or by small incisions. *Incised wounds*, and even wounds which are *contused and lacerated*, may be closed by sutures with safety, provided full aseptic precautions are taken. The hair must be cut away and the scalp shaved for an area of two or three inches from the wound in all directions, and all hair and foreign bodies should be picked out of the wound. The wound and the

surrounding skin should be washed with soap and water, then with turpentine or alcohol, and finally with the bichloride solution. If asepsis be secured, primary union can be obtained in wounds of the scalp as well as in other tissues, but if the edges are much contused and the scalp has been detached from the head, so as to leave ragged flaps, it is wiser not to insert many sutures, but to employ drainage. Any exposed bone should be covered, if possible, in order to avoid necrosis. Wounds in this region need very careful watching after suture, in order to prevent any retention of secretions, on account of the difficulty of providing for their natural escape. Burns and scalds of the scalp do not differ from those in other regions except in the loss of the hair.

Avulsion.—A characteristic injury of the scalp is its avulsion. In persons with long hair the latter may be caught in revolving machinery, and the entire scalp, or a large portion of it, may be torn directly from the head, leaving the pericranium exposed. (Fig. 630.) The shock of this accident

FIG. 630.



The scalp torn off. (Sick.)

FIG. 631.

The patient after recovery. (Sick.)

is very great, and the loss of blood may be considerable, so that death has occurred from these causes alone. Great care is necessary during recovery in order to preserve the patient's strength, on account of the constant loss of serum from so large a granulating surface, and deaths from exhaustion are not uncommon. These large wounds granulate, and are covered partly by contraction and partly by the epidermis growing from the edges. (Fig. 631.) Skin-grafting is usually necessary, and has cured many cases, the best method being that of Thiersch.

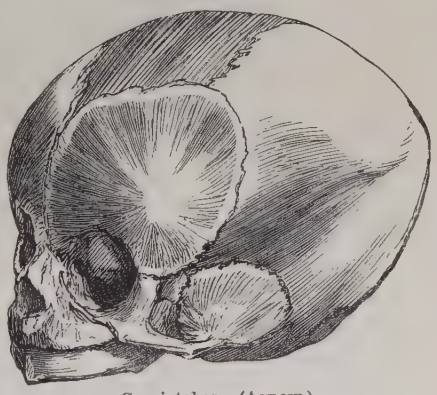
Inflammations.—Among the inflammatory conditions of the scalp is **dermatitis** due to infection or to irritation by chemicals. It has no special peculiarity. The hair must be kept short in order to maintain cleanliness. **Erysipelas** and **cellulitis** occurring on the head are very serious affections, because of the large amount of loose areolar tissue between the scalp and the pericranium, the meshes of which afford an excellent opportunity for the stagnation of serum and for the growth of bacteria, and also because of the liability that phlebitis may extend to the cerebral sinuses, or that meningitis may follow. On account of the thickness of the skin of the scalp, the secretion is apt to pocket and burrow in all directions instead of finding its way to the surface. Early and free incisions and constant watching of the infected area are necessary in order to prevent extension of the inflammation. Cellulitis is often followed by an ostitis and even necrosis of the bones of the skull.

Cicatrices.—The cicatrices of former wounds of the scalp may cause severe headache, neuralgia, or even epileptic attacks, and simple excision followed by primary union has cured these conditions. Hypertrophy may occur in these scars as elsewhere.

THE SKULL.

Hypertrophy and Atrophy.—In rare instances there is a uniform *hypertrophy* of the bones by an external new growth of bone, which does not lessen the cavity of the skull. (See Fig. 466.) Sometimes the bones of the face are involved, producing the condition of *leontiasis*. (See Fig. 471.) The opposite condition of atrophy is very rarely seen, although it may be so extreme that the pericranium and dura are in contact over considerable areas. Atrophy of the bones must not be confounded with craniotabes (Fig. 632), which is a not uncommon condition, evidently of rachitic origin, found in infants, in which the bones are so soft that they can be easily depressed by the finger, and may become flattened merely by the weight of the head as it rests on the pillow.

FIG. 632.



Craniotabes. (Agnew.)

Inflammation.—Osteomyelitis.—The bones of the skull are liable to the same diseases as the flat bones elsewhere in the body. An osteomyelitis in them is usually accompanied by periostitis and detachment of the pericranium. **Necrosis** is generally confined to the outer layer of the skull and the diploe, but occasionally sequestra are formed which involve the entire thickness of the bone and lie in contact with the dura mater. Osteomyelitis may be due to the staphylococcus or other pyogenic germs, or to the typhoid bacillus, or it may occur in tuberculosis and syphilis. The ordinary purulent osteomyelitis is generally caused by direct infection through a wound of the soft

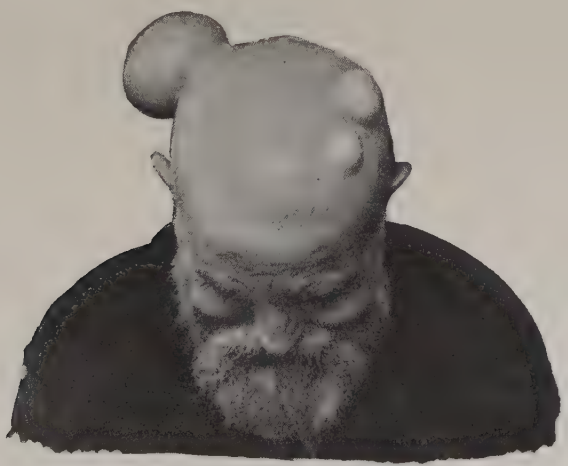
parts overlying the bone, especially if there is a contusion or some other injury of the bone. **Syphilitic osteomyelitis** is seen late in the disease, and frequently forms numerous large gummata beginning under the pericranium or in the bone, presenting flattened swellings scattered over the head, occasionally surrounded by a ring of new bone which forms a hyperostosis. A common result of syphilitic periostitis or ostitis of the skull is the production of large hard masses of permanent bone upon its surface. **Tubercular osteomyelitis** of the skull closely resembles the syphilitic form in its clinical appearances. The diagnosis between the two processes is exceedingly difficult, unless aided by the presence of other syphilitic or tuberculous lesions.

Treatment.—The treatment of necrosis of the skull consists in freely incising the abscesses, laying open the sinuses, cutting down on the diseased bone, and removing the latter with the curette or the chisel. Occasionally the sequestra are very slow in separating, and the process may last for months, even when the necrosed bone is only as thick as a piece of paper. When the sequestrum is loose it is easily removed, but when it is firmly adherent there is danger that attempts to remove it may cause a phlebitis of the diploe which may spread to the sinuses of the brain or result in pyæmia. But it is also dangerous to allow the sequestrum to remain, because pus is retained under the dead bone and acquires increased infectious power. An excellent method of treating superficial sequestra of large extent which have been in place for a long time and are still adherent is to perforate them with a drill at points about a quarter of an inch apart, the numerous openings allowing the granulation-tissue underneath to spring up so that the sequestrum will be loosened and thrown off. If this is insufficient the sequestrum may be removed by the chisel, but the surrounding bone should be freely cut away also, for its vitality is probably impaired, and it is likely to undergo further necrosis. It is also essential that the exposed bone should be covered with skin if possible, because otherwise it is liable to further necrosis. Flaps should be slid over the wound, therefore, and secured in place, allowance being made for drainage, or skin-grafting may be done. On account of the danger of acute osteomyelitis or acute infection of a wound in which the bone is exposed, every precaution should be taken by making free incisions to provide for drainage, and by keeping the parts as aseptic as possible. The large veins of the diploe communicate almost directly with the venous sinuses of the skull, and a phlebitis of the former may be communicated at once to the sinuses. All these veins are large and widely open, unable to contract, and not easy to block up, so that all the conditions are most favorable for the production of pyæmia, which is exceedingly common.

Tumors of the Scalp and Skull.—**Sebaceous Cysts.**—Among the most common tumors of the head are the sebaceous cysts or wens. They are found of all sizes, on all parts of the head, and often in great numbers. (Fig. 633.) The sacs of adjacent cysts occasionally communicate with each other. They sometimes attain a large size, and we have seen them twice as large as the fist, but they are of very slow growth and require years in order to reach this extreme size. Apart from the fact that they are a deformity

and an annoyance to the patient, they are of little clinical significance, unless they become inflamed, when they suppurate and form persistent sinuses, in which malignant tumors may develop. The inflammation, however, may be so acute as to destroy the lining membrane of the sac entirely and thus bring about a permanent cure. The sebaceous cysts present tense, fluctuating swellings covered with unaltered skin; but when inflamed, the skin becomes adherent and reddened, the surrounding parts become œdematous, and the tumor is more or less fixed. Theoretically, the cyst should always be adherent to the skin at the situation of the gland from which it originated by retention of secretion, and occasionally this point can be found and sebaceous material squeezed out, but more frequently the skin is entirely non-adherent. Even without inflammation, when the tumor has been in existence for a long time the skin is apt to be adherent, particularly if the wen is situated where it is exposed to pressure. In some instances the contents and even the wall of the cyst become calcified.

Fig. 633.



Sebaceous cysts of the scalp. (Case of Dr. F. H. Markoe.)

Treatment.—The only possible treatment of these tumors is removal, with entire extirpation of the sac, as described in the chapter on Tumors.

Dermoid Cysts.—Dermoid cysts are also found on the head, and must not be confounded with the ordinary sebaceous cyst. They can usually be distinguished by their situation, being most common in the region of the fontanelles, and also by the existence of a depression in the bone beneath them, due to their pressure during the development of the bone. Dermoid cysts, however, do not occur so frequently upon the scalp as upon the face. A meningocele is distinguished from a dermoid cyst by its reducibility, by its occasional pulsation, and especially by its usual situation at the root of the nose or on the occiput. Dermoid cysts are differentiated from wens by their peculiar situations, the depression in the bone beneath them, their lack of attachment to the skin, and their liability to be adherent to the skull. It is said that dermoid cysts are sometimes capable of being moulded under the

finger, their contents being thick enough to retain the impression of the finger-end like wax. This sign if it were present would distinguish the dermoids both from sebaceous cysts and from lipomata, but in our experience it is rarely discoverable. After incision the presence of hair within the sac confirms the diagnosis. The treatment of dermoid cysts is extirpation, with complete removal of the sac.

Angioma.—Tumors connected with the blood-vessels are exceedingly frequent upon the head. All the varieties of angioma, capillary, cavernous, and arterial, are to be found, and also aneurisms. The latter are generally of traumatic origin. Capillary angiomata and cavernous angiomata are particularly common on the head, about four-fifths of these tumors being found in this situation. They are especially common in children, and are almost always congenital, although generally very minute at birth. They sometimes attain a large size, and the vessels may communicate directly with the sinuses within the skull, a fact which should be remembered in operating upon these tumors when they are situated in the median line, particularly in the neighborhood of the fontanelles.

Treatment.—All the ordinary methods of treating angiomata are suitable for use upon the scalp, but excision is the best, because in this situation the scar is a matter of no moment and the hemorrhage is easily controlled by the pressure of an assistant's fingers around the edge of the tumor. A little dissection of the scalp generally allows the edges to be brought into good apposition, flaps being made if necessary.

Cirsoid Aneurism.—The arterial angioma, or so-called cirsoid aneurism, is almost limited to the arteries of the scalp, being seldom found in other parts of the body, and appears to bear some relation to the capillary angiomata, having become less common since the latter have been more thoroughly treated. Anatomically, the tumor consists of dilated arterial vessels running in all directions through a portion of the scalp and making it pulsate strongly. The disease is generally limited to one set of the terminal branches of the arteries, the temporal being most frequently affected, but sometimes the entire scalp is involved and the dilatation may extend backward along the carotid to the aorta. Occasionally connecting openings are formed between the veins and the arteries, thus making an aneurism by anastomosis and causing pulsation in the veins. No large tumor is formed, but a flat mass, composed of dilated vessels.

Treatment.—The treatment of cirsoid aneurism has proved exceedingly unsatisfactory. Multiple ligation of all the arteries which supply the aneurism, followed at the same sitting by ligature of the external carotid (on both sides in very extensive cases), is probably the best treatment.

Aneurisms.—Ordinary aneurisms do not differ from those in other situations. They are usually small and originate in an incised wound, being often seen in the temporal region, where stabs with a penknife or some sharp instrument have wounded a small artery and hemorrhage has been controlled by pressure, without cutting down upon and tying the artery at the bottom of the wound. Arterio-venous aneurisms of similar origin are also found. These small aneurisms are best treated by extirpation and ligation of the artery at both ends. Sacs containing blood connected with the

veins of the diploe or the sinuses within the skull sometimes develop as the result of injuries to the vessels by a contusion or fracture of the bone. These form soft, easily compressible tumors, which grow tense during expiratory efforts and occasionally pulsate with the brain when distended. They are rare tumors, but should be borne in mind in making a diagnosis.

Lipoma is rare, but a soft lipoma may closely resemble a sebaceous cyst. Congenital lipomata are found under the temporal fascia or between the pericranium and the skull, and depressions in the bone may exist under them, as under dermoid cysts. **Fibroma** when it occurs is more commonly a growth from the skin itself, and is often pedunculated. The scalp is a common situation for the fibro-neuromata growing from the sheath of the nerves, the so-called elephantiasis of the nerves, and they sometimes form extensive tumors like large folds of skin hanging down from the head and full of cord-like or vermiform masses.

Sarcoma forms a limited tumor, which may be hard in some parts and soft in others, and is apt to involve the skin early. Sarcomata frequently originate from some small granulating wound, and we have seen one growing from an ulcerating wen which resembled a large papilloma. Tumors formed of pure granulation-tissue are not infrequent, and the diagnosis of these tumors from sarcoma is not easy. We have sometimes found it possible to make the distinction by observing the method in which the granulation-tissue develops through the hair. Sarcoma grows beneath the skin and destroys the hair when the skin ulcerates, but exuberant granulations project over the sound skin among the hairs, surrounding the latter in such a way that they stand straight up through the mass of the tumor. Sarcomata of the scalp grow rapidly, ulcerate early, extend to the bone, and result in death either by hemorrhage or by early invasion of the cranial contents.

Fig. 634.

Epithelioma of the scalp of twenty years' duration.

Epithelioma of the scalp is quite common. In some cases it runs a slow and chronic course, like epithelioma of the skin in other situations, and we have observed one tumor which had grown for twenty years and involved the entire vertex of the skull and penetrated the bones for a considerable area. (Fig. 634.) This patient had no idea of the extent of the

disease, never suffered any pain, and finally died after a week's illness from meningitis due to infection of the ulcer. Epithelioma may, however, occur early in life, and we have observed it in a girl of eight years, in whom it began in the scar of a burn received at the age of two years, which had constantly remained ulcerated, never entirely healing over, the malignant changes probably commencing two years before we saw her. In this case also the epithelioma involved almost the entire scalp, and had destroyed a large portion of the bone. Bruns has reported a similar case. Unless malignant disease is seen very early, there is little hope of a cure, because both forms are apt to involve the bone, and it is then almost impossible to eradicate them completely, although the lymphatics may not be infected early.

Osteoma.—The bones of the skull are peculiarly liable to osteomata, which form on their external surface (very rarely on the internal) and are usually of the eburnated variety. They are most common on the frontal bone, and are generally small, flat, hard tumors, which are easily recognized. They are of little or no clinical significance, but may require removal on account of deformity or discomfort. They may be removed easily by the chisel, but the base in the diploe should be thoroughly chiselled out in order to avoid recurrence. Primary **malignant disease of the bones** of the skull is not very common, the tumor generally being secondary to tumors in other situations or to tumors in the dura mater or in the brain itself. Sarcomata originating in the diploe are sometimes covered with a thin shell of bone, which can be recognized by "egg-shell crackling," even when they attain a considerable size. In some cases secondary carcinoma forms cyst-like fluctuating masses filled with a clear jelly-like fluid, so that the diagnosis of sebaceous cyst may be made unless the existence of the primary tumor is known. Although operations for cancer of the skull are generally useless, some cures have been effected by extensive resection of the bones, even when it has also been necessary to remove a portion of adherent dura mater.

Pneumatocele.—Limited sacs in the connective tissue containing air are not infrequently found on the head, and the ordinary subcutaneous emphysema, originating in a penetrating wound of the air-passages or lungs, may extend to the head or may arise from perforating wounds of the frontal sinuses or other air-containing sinuses. Spontaneous perforation of the mastoid cells occurs in rare instances, in which case air may be driven into the surrounding tissue by forcible expiratory efforts.

Treatment.—Emphysema is to be kept down by a firm bandage and a pad over the point of escape of the air, if it be accessible. The air-sacs are to be incised, packed, and allowed to heal by granulation.

FRACTURES OF THE SKULL.

Fractures of the skull are more naturally considered with injuries of the head than with fractures of other bones, for they are chiefly important on account of the liability to complication with injury to the brain.

Mechanics of Fractures of the Skull.—The mechanics of fractures of the skull would be naturally supposed to depend in large part upon its shape and construction. According to Félizet, the skull may be considered as

formed of certain pillars or buttresses of thick bone, with thinner parts between, the pillars following the vertical or meridian lines from the base to the vertex, and he advanced the theory that fissures are apt to run in the thin bone between these pillars. But experience does not uphold this theory. Before Félizet, Aran had claimed that the fissures ran in definite and limited directions; thus, blows upon the anterior or posterior parts of the vertex would produce fissures running down to the corresponding portions of the base, and blows on the side of the head would involve the base on the same side. More recent investigators, however, find that only about one-third of the fractures appear to be governed by this assumed law of Aran.

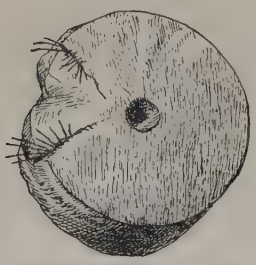
It is regarded as settled at present that the fissures take the direction of the force which produces them. If the skull is compressed in a vise and we consider the points of pressure to represent the poles of a globe, and that part of the skull half-way between them as its equator, we shall find that the skull is flattened by the pressure, the two poles being brought nearer together, while all the diameters running through the equator are lengthened, and its circumference is also increased at that point. Imaginary lines drawn through the poles on the surface of the skull perpendicular to the equator, like the meridians of a globe, would therefore tend to separate at the equator, and when fissures appear as the result of increasing pressure they would follow these meridian lines. The effect is the same whether the skull is compressed laterally, vertically, or from before backward, without reference to its shape, to its sutures, or to differences in the thickness of the bone. Not only is this true of forcible compression in a vise, but the same law holds of a blow received upon one side of the head, the inertia sufficing to make counter-pressure, and the fissures run in straight radiating lines from the pole where the blow is struck towards the opposite pole. These are known as the *bursting lines* of the skull. If the pressure applied by the vise in the experiment described above be very severe, and the skull very elastic, sometimes equatorial fissures will appear, either with or without the others. This equatorial fracture, when seen clinically, is produced, as a rule, by heavy bodies moving with a low velocity.

The *momentum* with which the blow is struck determines the occurrence of the fracture, and a light body propelled at a high velocity is capable of doing as much damage as a heavy body moving slowly. The character of the injury, however, varies with the *velocity* and the *weight* of the body. A small body moving with great velocity has a tendency to perforate the skull, whereas a large body with a low velocity does less damage at the point of impact, but is likely to produce more diffuse injury in other parts of the skull. The shape and character of that part of the striking body which comes in contact with the bone must be taken into consideration, for a pointed or sharp-edged body will tend to perforate the skull, while a blunt surface will be likely to produce fissures only.

The skull possesses great *elasticity*, as is proved by the change in its shape under strong pressure in a vise, as just described, by which the longitudinal diameter may be shortened as much as fifteen millimetres, the transverse diameters being lengthened at the same time without fracture, the skull returning to its original shape when the pressure is removed. A skull filled

with paraffin and dropped from a height will show a depression upon the surface of the paraffin even if the blow is insufficient to produce any fissure in the bone, proving that the latter has sprung inward under the blow. In children the skull is so soft that depressions of considerable area, and even one centimetre or more deep, may be produced without any signs of fracture of the bone, the latter simply bending inward like a stiff elastic piece of parchment, and springing back into place when elevated without a trace of a fissure. The elasticity of the skull is further shown by the fact that fissures open widely and then spring shut, for hairs or fragments of clothing or other foreign objects may be driven into the fissure while open and then retained there, as is proved by certain specimens. (Fig. 635.) In one case (Von Bergmann) a fragment of a bullet was found in the brain, with no trace of a former opening in the skull to show how it entered.

Fig. 635.



Trephine button of bone, showing hair caught in fissured fracture of the skull.

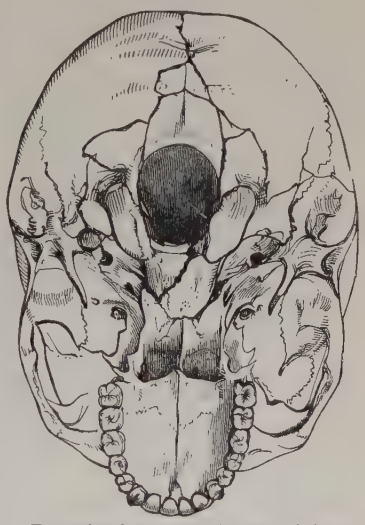
Contre-coup.—There has been much discussion as to the existence of fractures by *contre-coup*, by which is meant the occurrence of a fracture on the opposite side of the skull from that on which the blow is received. The original theory of fractures by *contre-coup* was that the motion and force of the blow radiated over the skull in different directions and met upon the opposite side, producing there so much commotion as to result in a fracture; but this explanation is now generally rejected. Such fractures may take place, but they must be very rare, for the majority of fractures supposed to have occurred in this way can be otherwise explained. A large number of the cases of supposed fracture by *contre-coup* are nothing more than cases of the extension of fissures from the opposite side of the head. Many others are to be explained by the simultaneous receipt of a blow on the other side of the head; thus, a man is struck upon the forehead, and the head is driven backward, so that the occiput strikes against a wall; or he is struck upon the vertex, and the spine resisting at the base produces a fracture at that point. A man struck on the head is apt to fall, and he might strike the other side of the head against the ground, or might fall upon the buttocks and the resulting jar upon the spine produce a fracture at the base. The supposed fractures by *contre-coup* are more often found in the base than in other parts of the skull, because the vertex is more exposed to direct blows; but in the great majority of fractures of the base by *contre-coup* the fissures can be traced directly from the vertex.

Fractures of the base do not differ much in the mechanics of their production from fractures of the vertex, but they are generally the result of indirect violence, except those produced by the penetration of bullets through the neck, or of bullets or pointed objects entering through the orbit, the nose, or the ear. The orbit is the usual seat of the latter injuries, and one of their peculiarities is the slight external mark of the injury, for a cane, a fencing-foil, or some such object may readily penetrate the fold of the conjunctiva or the upper lid, and the wound in the latter may be almost unnoticeable when the weapon has been withdrawn. Foreign bodies, such

as the ferrule of a cane, are also very commonly left in these wounds, the soft parts closing over them and giving no clue to their presence.

The usual fractures of the base are the results of severe blows upon the vertex, the fissures running down into the base. Another form is produced by the spine when the head is driven down upon it, or when a man falls upon the head and the weight of the body produces a fracture of the base. Félizet aptly compares these two accidents to the two methods by which the head of a hammer may be driven upon the handle either by striking the head and forcing it on directly or by striking the other end of the handle and driving the handle into the head, as the latter remains stationary by inertia. Fissures through the base follow the laws already laid down. Blows upon the forehead or upon the occiput are likely to produce longitudinal fissures; blows upon the side of the head produce transverse fissures; blows half-way between these points produce oblique fissures. Very severe blows by falls upon the feet or upon the head may force the spine into the skull and produce circular fissures surrounding the foramen magnum. (Fig. 636.) Similarly, blows upon the chin may drive the condyles of the jaw through the base of the skull. The clinoid processes may be torn off by the sudden tension of the tentorium in extensive fractures, but fissures seldom, if ever, run directly across the crista. It is in the base that the theory of Félizet as to the use of the buttresses of the skull should be particularly applicable, if it were based on facts, but even here the fissures follow the direction of the force, without much regard for the relative thickness of the bone in different portions. In spite of the strong buttresses of bone in some parts, the base is particularly susceptible to fracture, because of the large number of openings which it contains for the passage of vessels and nerves, and the many places in which the inner and the outer table lie in close contact, making a thin layer of bone without any diploe. According to Phelps, sixty per cent. of severe injuries of the head are accompanied by fracture of the base. In four of his cases the fissure could be traced directly down from the vertex.

Fig. 636.



Extensive fracture of the base of the skull. (Agnew.)

Diastasis of Sutures.—The sutures are occasionally forced apart by a violent crushing blow, and Phelps has recorded a case in which the temporal bone was torn loose from all its connections. Diastasis of the sutures is more common in children. (Fig. 637.) But diastasis is, after all, a rarity, the fissures in fracture of the skull being generally independent of the sutures. Fissures can often be found running close to a suture in a part of their course, and following it in another part, but leaving it abruptly again, and it would seem that the denticulated structure of the sutures is unfavorable to the occurrence of fissures.

Penetrating Fractures.—When a pointed or sharp-edged body strikes the skull, the outer table gives way, and the diploe may also be injured. If the force is then exhausted, the inner table may not be injured, but if the force continues to act, the inner table may be fractured also. (Fig. 638.) If the momentum is sufficient, the inner table may be perforated, fragments from it being displaced like those of the outer table or driven far

Fig. 637.

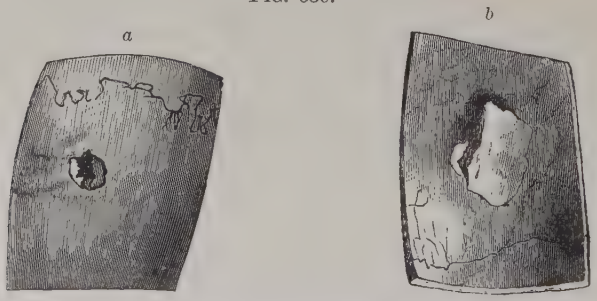
Fracture through the frontal suture. (After Agnew.)

Fig. 638.

Depressed fracture of the skull produced by a hammer. (After Agnew.)

inward and left detached in the brain. In these penetrating fractures the opening may be clean cut and without any surrounding fissures. Perforating wounds made by missiles of high velocity, such as bullets, present the same difference in the inner and outer tables as similar wounds of the soft parts, the wound of entrance being smaller than the wound of exit. (Fig. 639.) The outer table will be less extensively injured than the inner as the bullet

Fig. 639.



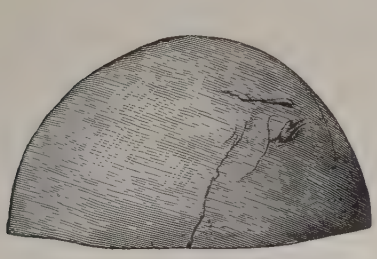
Gunshot fracture of the skull: *a*, external perforation; *b*, internal splintering. (Agnew.)

enters the skull, and the inner table less extensively injured as the bullet leaves it. When a blunt object of rather small area strikes upon the surface of the skull, the outer table is depressed and the diploe crushed, while the inner table may be simply fissured or may be depressed, the fissures or depressions being more extensive than those upon the outer table. Occa-

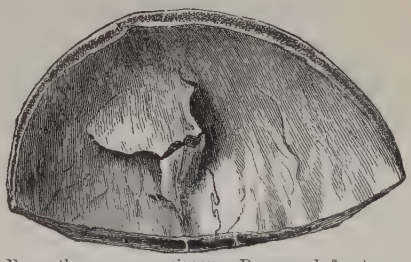
sionally considerable depression of the inner table will be found associated with a simple fissure or a punctured fracture of the outer table. Injury to the inner table without fracture of the outer is a very rare occurrence. The fact that the inner table is frequently more extensively injured than the outer was formerly supposed to be due to a difference in their resisting power, and the inner table was called the *vitrea*, or glass-like table. The external table is somewhat thicker than the inner, but one is not more brittle than the other, and the apparent difference between them is easily explained by certain mechanical principles:

(1) When the skull is struck by a moderately sharp-pointed object with a violence just short of that necessary to perforate it, the inner table must suffer more than the outer, because the force of the blow tends to spread in a wedge-shaped direction on all sides as it enters the bone, just as a nail splinters a board on the farther and unsupported side when driven through it. (Fig. 640.) The outer table is held in place by the diploe and is per-

FIG. 640.



Fissure of external table of the skull.

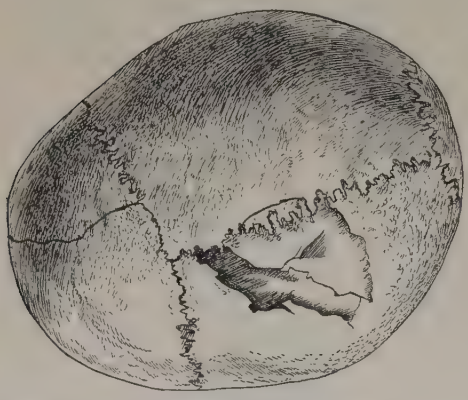


From the same specimen. Depressed fracture of internal table corresponding to the external fissure. (Agnew.)

forated, the inner table is not supported and yields, splintering instead of allowing its particles to be pushed aside laterally by the penetrating object. (2) If a stick be bent across the knee until it breaks, the fracture will begin on the side of the stick away from the knee, because that is the convex side of the curve. In the same way a blow on the skull first depresses the latter and reverses the curve, so that the inner table becomes the convex side and must yield, like the convex layer of the bent stick. Any force which acts from without and bends the skull inward has a tendency to press together the particles of the outer table, while those of the inner table are driven apart. This bending inward of the skull depends upon its elasticity, for if it were not elastic it would be splintered into fragments or crushed. (3) Another proof of the fact that the inner table is not more brittle than the outer is to be seen in certain pathological specimens of skulls in which gunshot wounds have been produced by a ball which penetrated the skull on one side, but was arrested on striking the other side and did not perforate it. At the second impact the blow is first felt by the internal table, and produces slight effect upon it, while the splintering of the outer table at that point is similar to that which is usually seen in the internal table when a non-penetrating blow has been delivered upon the external table first, as is usually the case.

When the skull is struck by a broader surface we find slightly different effects, fissures being caused instead of penetrating wounds, and these follow the laws already laid down. (Fig. 641.) Clean-cut fissures without depression are most commonly seen as the result of quick, sharp blows, such as might be given by a light club held in the hand, the motion of the latter being stopped by the hand at the instant that the club comes in contact with the head, for in this way the skull can be cracked with no tendency to the production of depression. If the force continues to act after the bone has yielded, the fragments are driven inward and a depressed fracture is produced, and usually impaction takes place.

Fig. 641.



Fracture of the skull produced by a bludgeon. (After Agnew.)

Compound Fractures.—Fractures of the skull complicated with external wounds are more serious than other compound fractures, because in addition to the danger from inflammation of the bone there is the possibility of deeper infection. When the infection is limited to the bone it results in limited suppuration, death of the fragments, separation of the periosteum, and consequent necrosis. Abscesses form, with phlegmonous inflammation of the scalp, the discharge from the wound increases and becomes serous, the edges become swollen and œdematous, burrowing takes place in various directions, and an acute ostitis of the skull bones follows. Not only is there danger of this infection spreading to the meninges, but there is great likelihood that a phlebitis may be set up on account of the intimate relations of the veins in the diploe to the sinuses, and the infection may then extend to the brain. Meningitis and encephalitis are among the most common results of these infected compound fractures.

Repair of Fractures.—The repair of fractures of the skull is effected like that of fractures of other bones, except that a very small amount of callus is thrown out. The limited bone reproduction is chiefly effected by the diploe, the periosteum taking but little part in the formation of new bone, and the dura mater even less. In fact, it is doubtful if any bone is produced by the dura. That the bones of the skull are capable of reproducing bone is shown by the manner in which fragments entirely isolated from the periosteum attach themselves to the surrounding bone, and by the fact that flaps of the pericranium turned up with only the outer layer of bone-cells will form new bone; but, as a rule, the production of bone is so slight that large openings remain permanently. The amount of bone which may be lost in consequence of compound fracture or of the subsequent necrosis is surprising, some individuals having borne the loss of one-half of the vertex, or one-fifth of the entire skull, without serious inconvenience. The gaps left by loss of bone may be filled by implanting a celluloid plate or by a

plastic operation like that suggested by König, who cuts a flap from the pericranium at the side of the opening, shaving off a thin layer of bone with it, turns it over into the defect with the bony side uppermost, and covers this with a flap of skin.

Any deformity which exists, particularly any depression of the inner table of the skull, is likely to be permanent. Sometimes spiculæ of bone are found attached at one end near an old fracture from which they originated and projecting far into the substance of the brain at their free extremity, with no sign of absorption or spontaneous removal. For these reasons it is important that all fractures with depression should be elevated when first seen, because of the dangerous results which are liable to develop later in life, such as brain abscess or epilepsy, due to displaced fragments, to adhesions of the brain to the dura, or to other causes of irritation.

Symptoms.—The local signs of fracture of the skull are not so marked as in fractures of other bones, and the deformity is usually slight unless large areas of the skull are affected or there is marked depression. Mobility is a much more constant sign, for small fragments can often be made to move when the bone is comminuted. Crepitus is seldom found. Local pain and tenderness are in some cases quite definite, and Phelps lays great stress on this symptom. In the early stages a hæmatoma forms, and œdema may persist during the stage of repair. A simple fissure in the skull without depression cannot be discovered through the scalp, but compound fractures are generally easily recognized.

Diagnosis.—The diagnosis of fractures of the vertex is in some cases very easy, in others difficult, or even impossible. A subcutaneous vein or a suture may feel like a fissure without depression. A narrow fissure in the bone may be difficult to discover, even when the surface of the bone is exposed for inspection. It can sometimes be recognized by the fact that the coagulated blood, which can be wiped from small grooves on the skull or from the sutures, remains fixed in the crack. The edges of a fissure are even and not toothed like the sutures. Fractures with depression are usually easy to discover, but a hæmatoma of the scalp, or blood effused under the pericranium like the caput succedaneum of the new-born child, often resembles a depressed fracture, for the centre of the tumor is soft and fluid while on the edge the clot may be hard, or new bone may be formed in a circular ridge. The distinction can be made by pressing in the centre with the finger, which will be able to feel bone at the bottom of the hollow in the clot, but not in the depression of a fracture. A careful examination of the edges will also assist, for in cases of depressed fracture the surface of the skull can generally be followed up to the edge of the depression without any change in level, whereas in the case of a hæmatoma the finger as it passes over the surface of the skull is raised at the edge of the tumor before it sinks into the hollow in the centre. A fresh blood-clot can often be dissipated by massage, so that the true relations are evident.

Cephalhæmatoma.—Some cases of fracture present pulsating tumors which can be felt at the site of the fracture, consisting of blood or cerebrospinal fluid, with an opening sufficiently large to transmit to them the pulsa-

tions of the brain beneath. These flat tumors are seldom tense, and the pulsation disappears in the course of a few hours or a few days. They are known by the name of cephalhæmatoma, or traumatic meningocele, the latter name being badly chosen, for even when they contain cerebro-spinal fluid there is no protrusion of the membranes. Protuberances on the outside of the skull, such as **syphilitic nodes, congenital deformities,** or **periosteal thickening,** may be misleading, but a careful study of the case, with examination of the other side of the head, where similar abnormalities will often be found, ought to settle all doubts. The diagnosis of fracture of the skull in many cases depends upon the symptoms caused by an accompanying injury of the brain. In doubtful cases, in which it seems important to determine the diagnosis at once, an **exploratory incision** may be made, but these incisions should be limited to those cases in which the symptoms of cerebral injury seem to demand surgical treatment. Although under antiseptic precautions these incisions are not dangerous, the general rule that no fracture should be converted from a simple to a compound one without some adequate cause is to be observed.

Diagnosis of Fracture of the Base of the Skull.—In fractures of the base some of the most important symptoms are the escape of blood from the ear, nose, or mouth, its appearance under the conjunctiva, or under the mucous membrane of the gum or the pharynx, the escape of the cerebro-spinal fluid from the same orifices, the discharge of brain fragments, and the indications of injury to the trunks of the nerves.

Hemorrhage.—Hemorrhage from the ear occurs in one-half of the fractures of the petrous portion of the temporal bone. It may be slight or very copious, but, as a rule, it is of short duration. Examination of the ear with the speculum should also be made, for fissures may be seen in the drum membrane after the hemorrhage has ceased. Sometimes there is no rupture of the membrane, and the blood escapes from the middle ear by the Eustachian tube. A few drops may follow a simple rupture of the drum, and blood may also collect in the middle ear behind an unruptured drum after a severe blow on the head without fracture of the skull. Bleeding from the nose or the mouth due to fracture of the base is very apt to be confounded with ordinary epistaxis or hemorrhage from other injuries. A fracture of the cribriform plate causes nasal hemorrhage. Blood issuing from the mouth may have run down from the nose, or may have come from the ear by way of the Eustachian tube. When hemorrhage is found under the conjunctiva, appearing some time after the injury, it indicates some deep orbital trouble, and usually implies fracture of the base, for ecchymosis due to injury of the conjunctiva itself forms immediately. Hemorrhage into the lids with ecchymosis is not so certain a sign, although if it appears long after subconjunctival hemorrhage has been noted it is safe to conclude that it has been caused by fracture. In a certain proportion of cases so much blood finds its way into the orbit as to cause exophthalmos. Ecchymosis appearing in front of the mastoid process and spreading upward and backward is characteristic of a fracture of the posterior fossa of the base.

Escape of Cerebro-Spinal Fluid.—Cerebro-spinal fluid escapes most frequently from the ear, and occasionally from the nose. It is rarely de-

tected in the mouth, although it may reach the latter through the Eustachian tube or from a fissure opening in the sphenoidal cells. It would find its way to the nose from a fissure through the ethmoidal cells, but to reach the ear it must escape through a fracture involving both the internal auditory canal and the middle ear which has torn the dura mater or the arachnoid where they are prolonged into sheaths around the auditory nerve, and also ruptured the drum membrane. It has been asserted that cerebro-spinal fluid may flow from the ear without a rupture of the tympanum, for fractures of the roof of the external auditory canal, or fractures through the middle ear which detached the soft parts from the bone without rupture and lacerated the lining of the canal more externally, might allow the escape of the fluid. Cerebro-spinal fluid is recognized by the large amount of salt which it contains and by its low percentage of albumin, which distinguishes it from blood-serum. The amount lost is sometimes very great, even as much as one thousand grammes; as a rule, however, there is only just enough to moisten the pillow. It usually appears when the hemorrhage from the ear has ceased, although it may not escape for twenty-four hours. The flow may continue for ten days, but generally lasts only two or three. It is said to be increased by compression on the internal jugulars and by strong expiratory effort; and these facts may be useful in the diagnosis. If the tympanic membrane should not be ruptured the fluid would probably find its way to the pharynx by means of the Eustachian tube, when there would be great difficulty in recognizing it, and even in the nose it resembles the thin discharge from the Schneiderian membrane. The escape of cerebro-spinal fluid from the ear is one of the commonest and most reliable symptoms of fracture of the base of the skull. The fluid is usually clear, but may become serous or even purulent. It has been erroneously claimed by some that cases of fracture of the base with escape of cerebro-spinal fluid are always fatal, but Park has observed three cases in which recovery took place although the fluid became purulent.

Fragments of brain-tissue often escape from the wound in cases of compound fracture of the skull, and they have occasionally been observed in the discharge from the ear and from the nose. A microscopic examination of the fragments would settle the diagnosis in any suspicious case. Although the discharge of brain-fragments indicates that the laceration of the brain-tissue has been tolerably extensive, it is by no means incompatible with life, for in many such cases recovery has taken place.

Injury to the Nerves.—In fractures of the base important nerves may be divided or pressed upon and a limited paralysis produced on the same side as the injury, and the exact situation of the fissure may thus be determined. Phelps was able to recognize a fracture passing through the Fallopian aqueduct from the presence of facial paralysis. Deafness, blindness, facial paralysis, and paralysis of the palatine, of the abducens, or of the oculo-motor nerves have all been observed as the result of fracture of the base. Damage to the optic nerve behind the point of entrance of the artery causes late atrophy of the optic disk, but in front of that point it produces changes as immediate as those of embolism. Paralysis of the facial nerve may also develop immediately or late (from two to eight days after the

fracture, the latter cases being caused by periostitis or inflammation of the middle ear), and the late paralysis is likely to recover spontaneously.

Prognosis.—The prognosis of an injury to the skull will depend upon the accompanying injury to its contents and upon the presence or absence of infection. Without brain injury and without infection the prognosis is excellent. If the brain has been injured, the prognosis depends upon the severity of that injury. If infection has taken place, the result depends upon its extent and intensity, and the prognosis is doubtful because the infection may cause phlebitis, meningitis, or encephalitis. The prognosis of fracture of the base is not so bad as is generally supposed, for many cases which end in recovery are probably unrecognized. Although statistics give nearly seventy per cent. mortality for this injury, König saw eight recoveries in ten cases, and other surgeons report equally good results. The recovery, however, may not be complete, and blindness, deafness, or other permanent nerve injury may result. The mortality of fractures confined to the ethmoid or orbital plates is only about one in seven.

Treatment.—The treatment of fractures of the skull depends chiefly upon two considerations: first, whether the contents of the skull have been injured, and secondly, whether the fracture is simple or compound.

Simple Fracture.—The treatment of a simple fracture of the skull will vary according as it is a fissure or a depressed fracture. In the first case nothing need be done, if there are no brain symptoms, except to keep the patient quiet with an ice-bag to the head; in the second case an operation is necessary. When there are symptoms of brain trouble which seems to be due to the depressed bone, the operation should be undertaken at once. Some assert the advisability of trephining in every case of fracture of the skull, but we should always bear in mind that the resulting gap in the skull may make a scar which will be as injurious as the lesion we seek to remedy. On the other hand, the old rule not to operate unless symptoms are present, even when there is depression, is incorrect, because we expose the patient to serious danger of subsequent epilepsy by leaving depressed bone in place. In cases where there are no immediate symptoms due to depression, the operation may be postponed until the patient has recovered from the shock of the injury; and it should be remembered that the depression may disappear spontaneously meanwhile, especially in children.

Compound fractures should be most carefully examined, and if there is no depression any loose fragments should be removed and the wound cleansed and treated like an open wound elsewhere. If the wound is thoroughly aseptic it may be sutured, but if there is any possibility of infection it should be left open and packed with gauze. When depressed bone is found in a compound fracture the fragments should be elevated with aseptic precautions, as described on page 725. In many of these cases an anæsthetic is not necessary, the coma being so deep that the patient is insensible to pain.

Punctured Fractures.—Fractures caused by small or pointed objects striking the skull with great violence, such as a pointed hammer-head or the end of a heavy stick, should always be explored by trephining, since it has been shown that punctured fractures are almost invariably followed by much more damage to the internal table and to the brain than would be

supposed from the slight injury found on the outside of the skull. All foreign bodies must be carefully removed, the edges of the bone being chiselled away if necessary to release them.

Fractures of the Base.—The treatment of fractures of the base is symptomatic, with the exception of maintaining the ear and nose in as aseptic a condition as possible, for infection from these cavities is one of the principal dangers of such fractures. The ear should be thoroughly wiped out with moist cotton, and the parts examined with the speculum. No irrigation should be employed, because of the possibility of carrying infection into the fissures. The canal should be carefully stuffed with iodoform gauze or sterilized cotton. The nose should be cleansed by the spray and with moist cotton, and irrigation avoided for the same reason. Punctured fractures of the orbit must be thoroughly explored, the soft parts being incised and the orbital ridge trephined if necessary to gain access to the base of the brain.

In fracture of the base involving any of the air-containing cavities, such as the nose or the frontal sinuses, the occurrence of emphysema or pneumatocele should be avoided by preventing strong expiratory efforts on the part of the patient, especially sneezing, and by applying a firm bandage to the head, with a pad over the fissure if it is accessible.

Gunshot Fractures of the Skull.—Mechanics.—We have already seen that gunshot wounds of entrance and exit show in the skull the same peculiarity as in the soft parts—that is, the wound is smaller at the point of entrance than at the point of exit; and this is true whether the ball enters the skull and fractures the external table first or leaves it and penetrates the same table last. Bullets which strike the skull at a tangent may produce very serious internal effects without inflicting much external damage, for there may be merely a groove on the surface of the bone, and yet the internal table may be deeply depressed, the dura separated, and the brain severely contused. The effect produced by a ball depends largely upon its velocity. With the older fire-arms a velocity of two hundred metres per second was obtained, and this was sufficient to produce sharply cut openings in the skull without any fissuring. With the modern weapons, however, in which a velocity of from three hundred to four hundred metres per second is attained, very peculiar effects are produced, resembling those which would follow an explosion taking place within the skull, the fissures extending in all directions from the points of entrance and exit, and the brain-matter being forced out of these openings.

The generally accepted theory is that these effects are caused by hydrostatic pressure. For the purposes of experiment the contents of the skull may be considered fluid. If one of these high-velocity bullets is fired into a sealed metal can completely filled with fluid, as the fluid is incompressible and the ball enters so suddenly as to give no opportunity for the can to alter its shape or increase its capacity in any way, the sudden addition of the bullet to the contents of the can has the same effect as if an explosive had been discharged within the latter, and it is blown to pieces. A similar explosive effect takes place in the skull when full of brain or fluid; and it has also been observed in such organs as the liver, in which a mass of soft tissue is en-

closed in a capsule. An empty skull is simply perforated by the bullet without being shattered to pieces. That the explosive effect depends entirely upon the velocity of the missile is proved by the fact that it does not occur unless a certain velocity is attained. It should be noted that complete closure of the can or the skull in this experiment is not necessary, the same effects being produced when the bullet is fired into a skull filled with water and standing with the open foramen magnum uppermost. This hydrostatic theory is not accepted by all, but it is the most reasonable yet offered.

Clinical Effects.—The effects of gunshot wounds of the head depend upon their situation. The most serious are those which involve the ear, the orbit, or the mouth, especially when inflicted at short range with suicidal intent, as is frequently seen in civil practice. Wounds of the orbit are less dangerous when the roof is injured than when the apex is involved, the mortality in the latter case being eighty per cent. (Berlin). Wounds of the ear may cause injury to any of the important structures connected with or situated near that organ, deafness, facial paralysis, or interference with the motions of the jaw being common. Loss of equilibrium may result from injury to the semicircular canals. Severe hemorrhage is common in such wounds, on account of the proximity of the great vessels. The effects of shots in the mouth will vary with the position of the head, according as the latter is thrown far back and the barrel of the weapon directed against the roof of the mouth, or as the barrel points directly backward while the head is held horizontally. Wounds of the frontal and other anterior sinuses are likely to occur in the first position, and will be indicated by the presence of ecchymosis of the eyelids or of emphysema, while in the other position the injuries will be similar to those of severe fractures of the base.

Treatment.—The treatment of gunshot fractures is the same as that of other compound fractures, their only peculiarities being their extent and the frequent occurrence of foreign bodies in them. Foreign bodies should be removed if easily reached, but not otherwise. The bullet may traverse the brain and rebound from the other side of the skull at any angle, or if it be arrested in the brain it may settle down by gravity, quite out of line with the canal of entrance, and it may be impossible to find it even at autopsy. A long search would be necessary in such cases if an attempt were made to remove it by an operation, and might result in more damage than would be caused by the foreign body. The latter should, however, be removed if not too difficult of access, for Wharton has shown in a large series of cases that the mortality was nearly twice as great when the bullet was left in the skull, even in pre-antiseptic times. A ball or other metallic foreign body is easily found by Girdner's telephonic probe. (See page 227.) Bullets may be recognized in this way at a great depth, but it is better to leave them in place than to undertake formidable operations for their removal. If this instrument is not available, a light aluminum probe (Fluhrer) should be employed. If the probe is passed in nearly to the opposite side of the head, the nearest spot to the end within the skull can be determined by securing several threads to the projecting end and bringing them around the skull on different sides, like the meridian lines of a globe. If all of these are kept exactly in the same plane as the probe, their point of junction on

the opposite side of the skull will indicate the spot nearest to the inner end of the instrument (Bryant). The Röntgen rays will also reveal the presence of bullets and of certain foreign bodies within the skull.

THE BRAIN AND MEMBRANES.

Injuries of the Brain and Membranes.—Concussion and Compression.—The two conditions most frequently met with and most important in cases of injuries of the brain are concussion and compression. By concussion is meant a set of symptoms which are due to the severe physical commotion of the brain-tissues at the time of injury, although the shock may not be severe enough to produce any anatomical lesions. By compression, on the other hand, is meant a set of symptoms which are due to the pressure on the brain exerted by depressed bone or various other causes. The possibility of true concussion has been strongly denied, but many good authorities still believe in its existence, although it is certainly rare.

Concussion.—According to Duret and Miles, concussion is the result of the mechanical driving of the cerebro-spinal fluid into the fourth ventricle from the larger cranial cavities by the force of the blow upon the elastic skull, and of the pressure of the fluid in that situation on the important centres of respiration and circulation. Polis, who succeeded in producing fatal concussion in animals by a single blow without any visible lesions, accepts Duret's conclusions in part. But he considers the effect of such a blow to be double, as it acts upon the blood-vessels as well as upon the nerve-cells, causing cerebral anæmia at the same time that the shock suspends or weakens the functional activity of the cells. This theory plausibly explains the varying effects produced in different individuals by blows of equal force, for the effect may be dependent upon the state of the cerebral circulation in the individual. The centre of respiration suffers most in concussion, and that function is suspended before the heart ceases to beat: therefore Polis suggests the employment of artificial respiration as the best possible treatment for concussion with marked respiratory failure.

It is impossible to distinguish clinically between instances of pure concussion and those cases in which similar symptoms are due to very slight lesions of the brain, such as contusions, lacerations, or small capillary hemorrhages, and all these conditions must therefore be studied together. There can be no question that these slight injuries to the brain can be produced by light blows upon the skull, for thin microscopic cover-glasses inserted in the brain of a cadaver can be broken by blows upon the skull which do not break the latter. It has been found that the glass is broken only when it lies near the inner surface of the cranium, and that the force appears to operate most strongly in the line of application of the blow, more damage being produced to the pieces of glass in that line than elsewhere (Deucher, Kocher). These experiments show an analogy with the laws governing fractures of the skull, and prove that the principal injury to the brain is near the skull in cases of concussion, a conclusion which is in harmony with the clinical fact that unconsciousness is the chief symptom in concussion, indicating a disturbance of the functions of the cortex as the main cause of that condition.

Contusion of the Brain.—The anatomical changes produced in the brain by contusion consist of small capillary hemorrhages, and the brain looks red and œdematous and feels pulpy and softened. If infection from without takes place, the contused tissue breaks down, but otherwise it rarely forms an abscess, for, although it is possible for bacteria carried by the circulating blood to infect the injured tissues and produce an abscess, this is a very rare occurrence. Contusion may be the direct effect of the blow, which may drive the skull inward upon the brain, and a fatal injury may follow such a blow even without fracture, owing to the elasticity of the bone. Contusion has been seen as the result of contre-coup, and it is supposed by some that a severe blow might drive the soft brain from one side of the skull to the other, so as to cause even greater injury to it there than upon the side struck by the blow. Others, however, prefer the explanation that the distal injury occurs because it is in the line of the direction of the force, as in the experiments with glass just referred to.

Laceration of the brain, if extensive, appears like any other brain wound, and slight laceration is shown by the existence of minute multiple capillary hemorrhages. Laceration and hemorrhage in the brain have also been found as the result of contre-coup.

Symptoms.—Clinically we may group under one heading these four conditions, pure concussion, slight contusion, multiple minute lacerations, and capillary hemorrhages, for the symptoms are so much alike that it is impossible to distinguish them. The grade of the symptoms depends upon the number of the minute lesions—that is, it depends upon the extent of the damage to the brain. The patient is found in a drowsy, relaxed condition, pale, with superficial respiration, the pulse small and beating from 100 to 120 to the minute. The symptoms closely resemble those of shock, except the unconsciousness, which is more marked than in shock. Vomiting is generally present, but only of the contents of the stomach, and usually ceases when that organ has been emptied. There is no true paralysis, even of sensation, but the bladder and rectum may be evacuated unconsciously on account of the relaxation of the sphincters. The pupils may be contracted or dilated, or unequal, but they react to light. In severe cases the vitality of the patient seems suspended, and it may be impossible to arouse him; the respiration is irregular, superficial, sighing, and may be of the Cheyne-Stokes variety; the pulse is feeble, but may remain slow; copious perspiration appears; vomiting may be persistent, and convulsions may occur. The temperature in these cases is subnormal, becoming normal on recovery, and occasionally there is a reaction to 101° F. (38° C.), or even 103° F. (39.5° C.), and vomiting may then take place. This stage of reaction may be marked by great irritability, delirium, or mental disturbance which may last for days or weeks, or even permanently. In some cases there is nervous excitement from the beginning, the patient crying out and throwing the body and limbs about, although he appears unconscious of his surroundings. He may lie quietly upon his side with his knees drawn up, and may resist with a show of anger any attempt to change his position. This cerebral irritability (Erichsen) is most frequently found with slight laceration of the brain.

The **diagnosis** of concussion from alcoholism and apoplexy is important. In alcoholism the temperature is subnormal, and in apoplexy it is also often subnormal, but it may rise to the normal or higher if the issue threatens to be fatal. There will be less prostration in alcoholism, and in apoplexy there will be symptoms of compression. The **prognosis** is generally good unless grave lesions exist which are masked by the condition of concussion, although some cases end fatally from this amount of injury alone. The symptoms usually subside by degrees, the patient falling into a gentle sleep and awaking quite restored, but often feeble and tremulous. Vertigo and headache may persist for some time.

Treatment.—The treatment consists of rest, the application of an ice-cap to the head, and hot bottles to the feet. The feeble pulse demands the recumbent position, but the head should be elevated as soon as the improvement in the pulse allows, in order to favor the arrest of any hemorrhage which may be going on. If the vomiting prevents feeding by the mouth, nutriment must be administered by the rectum. The too free use of stimulants is to be avoided, on account of the liability of setting up too much excitement in the stage of reaction, and ammonia or ether is preferable to alcohol for the same reason, as their effect is more evanescent. The whole safety of the patient lies in not aggravating the lesions which exist in the brain, and for this reason every precaution must be taken to avoid anything which may increase the existing hemorrhage or other condition, for in every case marked by true unconsciousness it should be considered certain that some grave lesion of the brain has been produced by the injury. Morphine or the bromides may be used with discretion in the stage of restlessness, and calomel with morphine or Dover's powder in small doses as a sedative. A patient who has suffered from a severe concussion of the brain should be kept in bed on light diet and free from all excitement for ten days or a fortnight.

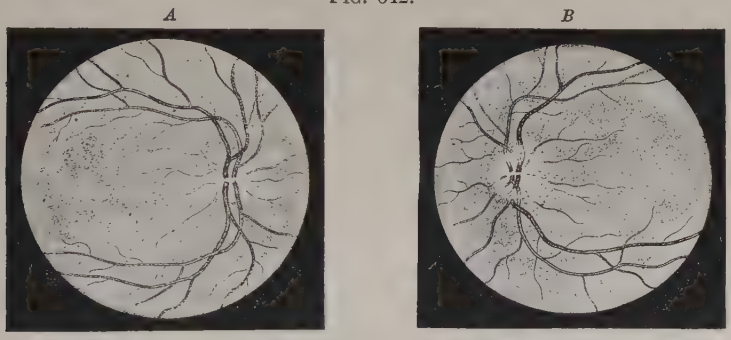
Compression.—Pathology.—When the internal capacity of the skull is diminished in any way, as by a depressed fracture, a hemorrhage, the entrance of a foreign body, the accumulation of pus, or the growth of a tumor, a condition may develop which is known as compression of the brain. Although the symptoms of this condition are characteristic and constant, its exact pathology is not yet understood. The theory most acceptable at present appears to be the following. The only variable contents of the skull are the cerebro-spinal fluid and the blood contained in the blood-vessels. The cerebro-spinal fluid surrounds the brain, and a large quantity of it is also contained in the ventricles. The first effect of increased pressure within the skull is to drive out a part of the cerebro-spinal fluid, some of which finds a ready escape by way of the foramen magnum, passing down along the spinal cord. The membranes between the vertebral arches are somewhat distensible, and this escape, therefore, affords considerable relief to the pressure within the skull. The cerebro-spinal cavities, such as the arachnoid and the ventricles, all communicate with the lymphatic system, and whenever the pressure becomes extreme, absorption of the fluid is increased. The quantity of cerebro-spinal fluid within the skull is thus reduced, some additional space is gained, and the compression is equalized. This relief is evidently limited, and a certain amount of the fluid

must remain in the ventricles, because the increasing pressure closes the passages leading from them; even in the severest cases of compression an autopsy always reveals some fluid remaining in these cavities. The next effect of the pressure is to lessen the amount of blood in the brain by compressing the veins and even the sinuses, but this at once increases the capillary blood-pressure because of the increased resistance caused by the compressed veins. This resistance may increase without marked changes until it equals the normal arterial blood-pressure, but the moment it reaches this point no blood can enter the skull; the centres of circulation are then stimulated by the stagnation of the blood, the heart-beat becomes more forcible, the pulse growing very slow but strong, and the circulation in the brain becomes restored in spite of the increased resistance, and therefore a certain amount of blood must always remain in the cerebral vessels. It has been shown that the arterial blood-pressure in the carotids may be nearly doubled in such cases. Up to the point of increasing the normal arterial blood-pressure, then, the space occupied by the compressing body may be equalized by the less amount of blood contained in the blood-vessels. But this compensation is also limited in amount, and if the pressure is further increased the brain itself becomes compressed. As the brain is a semi-fluid body, the pressure is diffused through the whole mass with practical equality, and the effect produced is general compression of the brain, for the pressure does not act upon any particular function or local centre. But if the compressing object be of limited area and situated over some one centre, one of the motor centres in the cortex for instance, as the brain is not entirely fluid and does not yield perfectly before the compressing body, the part directly under the latter will especially feel the pressure, and therefore local symptoms of paralysis or irritation will be produced.

Choked Disk.—A double sheath extends downward over the optic nerve as it passes through the optic foramen, the outer sheath being formed from the dura mater and the inner from the arachnoid, a free space existing between the two sheaths, and also between the inner sheath and the nerve. The vessels pass through the centre of the nerve to the retina. When the pressure of the cerebro-spinal fluid is increased it may escape along the optic nerve in the space between the arachnoid and the dura, or in that under the arachnoid; or if there is an effusion of blood into the subdural or the subarachnoid spaces it may also find its way between the sheath and the nerve through the optic foramen. In either case the fluid or blood compresses the nerve where it is confined by the edges of the bone and interferes with the circulation, particularly in the vein, causing a venous congestion, followed by œdema of the retina. At the same time, however, the artery is compressed, and arterial anæmia is to be observed in the retina. These changes are known by the name of *choked disk*, on account of the swollen condition of the optic disk. (Fig. 642.) They finally result in neuritis, atrophy of the nerve, and complete loss of sight. It should be remarked, however, that a few good observers hold that the changes in the circulation and in the optic nerve are not entirely due to pressure, and it is claimed that a cerebral tumor might produce them by some irritating substances formed in the growth which reach the optic nerve through the lymphatics.

Symptoms.—The symptoms of compression of the brain vary with the intensity of the pressure and the area of the compressing body. If the compressing body be of small area, the point of a depressed fracture, a small clot, or a small tumor, the size of which is not sufficient to diminish seriously the capacity of the skull, the symptoms may be limited to that part of the brain upon which the tumor or fracture presses. If the point of pressure be over one of the motor centres, a limited paralysis of one limb or of the face may be produced without other symptoms of cerebral compression; but even when the pressure affects the most limited area there is apt to be a little mental dulness and some choked disk. Before the pressure is severe enough to cause paralysis it irritates the centre and causes epileptic convulsions in the muscles connected with it. When the pressure is general over the entire brain, the symptoms vary according to its severity and also according to the rapidity of its production, very serious symptoms being produced by pressure suddenly applied, while the brain appears to grow accustomed to quite severe pressure if applied slowly.

FIG. 642.



A, normal retina; *B*, retina in choked disk. (Bramwell.)

In cases in which the compression is suddenly applied, the symptoms begin with a *stage of irritation*, shown by restlessness, insomnia, delirium, or, rarely, convulsions. Headache gradually develops, and the pulse may be hard and slow, indicating the irritation of the centres of circulation. In the second or *paralytic stage* the delirium gives way to drowsiness, the pulse is very slow, and may even be reduced to forty beats in the minute, but is hard and full, the face is flushed, and the respiration slow and stertorous. The patient can still be roused, and will answer questions, although slowly and after a considerable interval, and he will be apt to fall asleep in the middle of a word while talking. If the chief point of pressure is well forward over the frontal region, there may be diminished mental power and loss of memory. The pupils are apt to be sluggish, in the first stage contracted, later dilated on one or both sides, but especially on the side where the pressure is exerted. Local convulsions, paralysis, or even hemiplegia are observed, and sometimes the extent of the lesion may be determined by the situation of the paralysis if it be strictly localized. In uncomplicated cases the temperature is normal. The stupor gradually develops into coma, and finally the *stage of dissolution* appears, in which the slow, full pulse becomes

rapid and small, the respiration grows quicker and shallower, and the flushed face becomes pale. The coma may be so deep that operations can be performed without anæsthesia, with no evidence of sensation on the part of the patient. The respiration usually ceases before the heart, and the unconsciousness continues up to the last moment, gradually increasing.

Diagnosis.—Compression of the brain may exist without the characteristic symptoms of the pulse and respiration, and, as Kocher puts it, the surgeon who delays action until the full development of the typical pulse and respiration will often be too late to save his patient. The diagnosis must frequently be made simply from the fact of unconsciousness in connection with the history and the method of its development. In concussion the unconsciousness appears at once; it tends to lessen with the lapse of time, and it is not quite so deep as in compression. In compression the unconsciousness may not appear for a considerable interval after the accident, and it usually has a tendency to grow worse rather than better. It will be seen that it is not simply the condition in which the patient lies at the time when the surgeon sees him which determines the diagnosis, but that it is essential to consider fully the exact mode of development of that condition.

Prognosis.—If not relieved by operation, the symptoms of compression usually grow worse and terminate fatally. The pressure may be relieved spontaneously, however, or the brain may grow accustomed to it and a slow recovery may follow. The symptoms may also remain stationary, being finally relieved by operation. The prognosis is good if the cause is capable of removal and is removed early, and it is especially good in cases of depressed fracture if there is no other lesion of the brain.

Treatment.—The only possible treatment is the mechanical removal of the cause of the compression by an operation. The operation should be done in the first stages, if possible, when the only symptoms are those of irritation, such as restlessness and local twitchings of muscles, and before the retinal changes have gone beyond venous congestion. If the pressure is allowed to continue longer, the brain is liable to suffer from atrophy, calcification of the nerve-cells, or complete softening, and damage will be caused which cannot be repaired.

Wounds and Contusion of the Brain.—In considering the effect of **incised wounds** of the brain, their situation and direction are matters of the greatest importance. The cortex consists of a mass of cells with prolongations which extend directly downward into the centrum ovale of the brain to connect with their proper nerves. Incised wounds of the cortex, therefore, so long as they are directed vertically to the surface, even if they extend deeply into the centrum ovale, cause little injury, merely destroying a few fibres or cells. Incised wounds, however, which pass through the cortex parallel or nearly parallel with the external surface, entirely cut off the connection between the cortical parts and the fibres of the centrum ovale. Wounds through the centrum ovale in this direction would also divide a very large number of fibres, and so throw out of action an equally large part of the cortex. Considerable **loss of substance** may occur in the brain as the result of injury or operation, and, if no important centres exist in the region involved, the effect is not serious, as is shown by the well-

known case in which a crowbar was driven endwise entirely through the head and the patient recovered with but slight loss of his faculties.

Contusion of the brain has already been described in speaking of concussion (page 706), and in slight cases these conditions cannot be distinguished, but severe contusions may destroy large portions of the brain, resulting in paralysis or loss of mental power. Cheyne-Stokes respiration is a common symptom of contusion, and is occasionally associated with albuminuria or glycosuria from injury to the fourth ventricle. If hemorrhage occurs it is apt to cause signs of compression, which are absent in simple contusion; but contusion without hemorrhage is quite rare. When an external wound is present the contused tissues often suppurate, but otherwise the danger of abscess from this source is very slight. Broncho-pneumonia and other lung complications are frequent. The symptoms of **laceration** of the brain in the slighter grades also resemble those of concussion. The severer forms produce the same effects as extensive wounds, and are usually fatal on account of the hemorrhage.

Prognosis.—The dangers of injury to the brain by incision, contusion, or laceration are various. (1) *The part affected* is important, for motor paralysis, for instance, results from an injury to the motor centres, while an injury to the frontal lobe seems to be of comparatively little significance, although when very extensive it results in loss of mental power. (2) *Hemorrhage* may be fatal from compression as well as from loss of blood. (See next section.) (3) *Infection* may take place in any wound that is exposed, this danger being naturally greatest when the brain-tissue has been badly injured by contusion or laceration. (4) *Œdema*, apparently due to a traumatic vascular paralysis extending throughout the brain, may occur and cause fatal compression. (5) Finally, there is the danger of *fungus cerebri*, which was formerly considered to be a protrusion of brain-matter through an open wound, but later researches have shown that the protruding mass is not a portion of the brain, but is mainly loose granulation-tissue, and that the exuberant granulations are due to infection. In a granulating wound, or in a wound that has not yet begun to granulate, in which the brain is exposed, the tissues suddenly begin to grow out through the skull, spreading over the edges, and forming a tumor with a pale, somewhat sloughing surface, which bleeds readily. There are no brain symptoms unless meningitis or encephalitis be present.

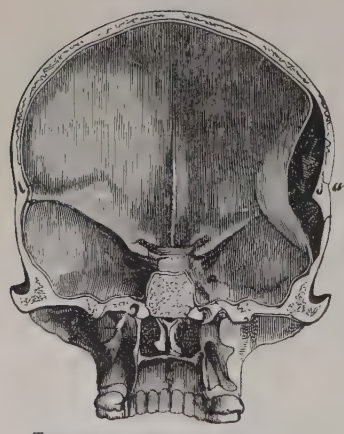
Treatment.—In general it must be emphasized that every penetrating wound of the brain should be thoroughly examined by cutting away the edges of the opening in the skull, in order to remove foreign bodies and blood-clots and afford free drainage, and to ascertain the exact extent of the injury and the condition of the parts, which are then to be treated as described elsewhere. The hemorrhage from wounds of the brain is often considerable, and is difficult to control, because the vessels have such delicate walls and lie in such friable tissue that it is impossible to apply ligatures. It can be arrested by passing ligatures around the vessel, introducing them with curved needles, or by packing the wound with sterile gauze. The wound should be thoroughly covered and a tight bandage applied, otherwise hernia cerebri may develop. The treatment of hernia cerebri consists in cutting

away the mass, cauterizing the base, and applying pressure by a flat metal or other plate. This complication in pre-antiseptic times appears to have had a very high mortality, but it is no longer so common or so dangerous.

Intracranial Hemorrhage.—Hemorrhage within the skull may be extradural, between the dura and the bone; intradural, between the brain and the dura mater; or cerebral. **Cerebral hemorrhage** is of comparatively little interest to the surgeon, although Dennis has recommended the use of the trephine and evacuation of clots in certain cases, and Keen has advised ligation of the carotid in progressive apoplexy with hemiplegia. It is seldom that a hemorrhage in the brain can be localized, even when the exact situation of the causal injury is known. **Hemorrhage beneath the dura** may take place in the meshes of the subarachnoid space, and small clots are then seen lying in the various fissures. It may also appear between the pia and the dura, the brain usually receding and leaving a space, so that the blood is apt to settle at the base. Occasionally, however, the hemorrhage may be limited by adhesions or some other cause, and a large clot may form on the surface, which may cause symptoms similar to those of the extradural hemorrhages next to be described.

Extradural hemorrhage occurs from the middle meningeal arteries, particularly their anterior branches, and in rare cases from the sinuses. The artery sometimes runs in a complete canal in the bone, and is generally injured by a direct blow in the line of its course, but a fissure starting elsewhere may extend across the canal. The artery is often lacerated by a blow not sufficiently severe to cause fracture, and there are well-certified cases in which the injury has been caused by contre-coup, a blow on the right side of the head, for instance, causing a rupture of the artery upon the other side; and it is not difficult to believe that if the dura is torn from the bone by the effect of contre-coup the artery might be injured when it lies directly on the dura. The escaping blood in such an injury collects between the dura and the bone, forming a clot which is usually rather large and flat, but which may attain a considerable thickness at one point. (Fig. 643.)

Fig. 643.



Transverse section of skull and dura mater, showing extradural clot at *a*. (Agnew.)

Symptoms.—The symptoms of hemorrhage into the brain or between the brain and the dura vary according to the rapidity and extent of the extravasation. If the amount of blood is great and it is suddenly thrown out, there is immediate unconsciousness, with symptoms of shock and of concussion, and the coma may gradually deepen until death occurs, or it may cease and the patient may recover, with absorption and shrinkage of the clot. The pupils are contracted at first, then dilated, particularly upon the side on which the clot lies, and they are sluggish in responding to light. After reaction has set in, a rise of temperature is

probable, reaching to 100° F. (37.8° C.) or 101° F. (38.3° C.). In the case of multiple small hemorrhages, as has already been noticed, the symptoms are similar to those of concussion of the brain. Extradural bleeding occurs slowly, and although the clot lies near the motor centres it is not until it has attained a considerable size that symptoms of paralysis appear. It is therefore characteristic of this kind of hemorrhage for the symptoms to appear some hours or even days after the injury, the patient seeming quite well in the mean time. Sometimes he manifests a limited local paralysis in the first stage before symptoms of general compression of the brain appear. In exceptional cases the symptoms have begun immediately after the injury, but it is evident that there may be early symptoms due to other causes, such as concussion of the brain, which may mask the free interval. The usual course of these cases is as follows. A man who has received a severe blow upon the head feels somewhat shaken or even stunned, but recovers himself in a few minutes and then goes about as usual. Suddenly he feels a weakness in the hand or leg, which increases to actual paralysis, and may extend until hemiplegia is produced, with aphasia. Symptoms of cerebral compression then appear, sometimes accompanied by epileptic or spastic convulsions; the patient begins to be stupid, and finally falls into coma. The pupils are sluggish and are apt to be contracted in the first stage, then widely dilated upon the side on which the clot is situated, especially if the blood gravitate to the base. The presence of aphasia indicates an extension of the clot forward, and the existence of anæsthesia a backward extension. Although the interval without symptoms is generally considered diagnostic, the same course is occasionally seen in hemorrhage under the dura, where the clot is localized from some cause, so that an absolute diagnosis may be impossible.

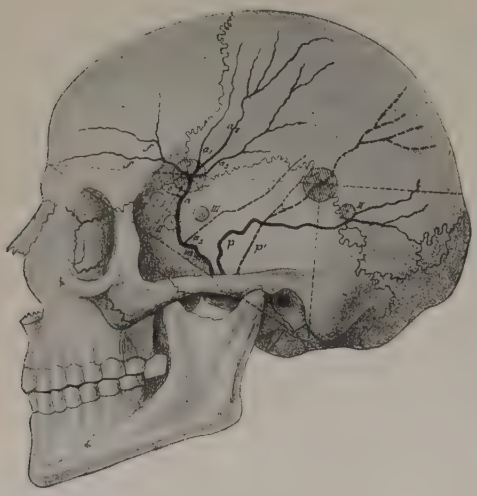
The paralysis in extradural hemorrhage appears upon the opposite side from the situation of the clot, except in a very small percentage of cases which are as yet inexplicable. Subdural hemorrhage often causes paralysis of the cranial nerves of the same side as the blood settles to the base and presses on the nerves themselves and not on their centres, a fact which may aid in determining the site of the clot.

Prognosis.—The prognosis of intracranial hemorrhage is very grave even in the extradural form, where the opportunities for spontaneous arrest are the best, for only about ten per cent. of recoveries by expectant treatment are found in this variety. Small blood-clots may be absorbed, but large clots, especially in the brain, are apt to be converted into a loose cellular tissue with cysts in its meshes, sometimes of very large size. These cysts result in atrophy of the brain and are common causes of epilepsy.

Treatment.—In extradural hemorrhage the clot may be reached by a trephine opening at the crossing of two lines, the first of which is drawn two finger-breadths above the zygoma and the second one finger-breadth, or rather more, posterior to the posterior edge of the malar bone at its junction with the zygoma. This opening strikes the anterior branch of the meningeal artery, and will be likely to reach the clot above this point or below, the two favorite situations for these extradural clots. (Fig. 644.) Steiner recommends drawing a line from the glabella to the tip of the mas-

toid process, and a second line perpendicular to the former at its middle point. The anterior branch of the artery will be found at the junction of this second line with a horizontal line drawn through the glabella. (Fig. 644.) The point where the last-mentioned line intersects a vertical through the tip of the mastoid is the proper place to apply the trephine for hemorrhage from the posterior branch. These cases may also be treated by turning down an osteoplastic flap and thus thoroughly exposing the vessels. The hemorrhage will have ceased at the time of operation, and the clot should be washed out and another trephine opening made at the most dependent portion of the cavity, if necessary, to obtain thorough drainage. If no blood is found external to the dura, when the skull is opened, the dura should be incised. Intradural hemorrhage usually arises from the middle cerebral artery, and the clot will be situated so as to be accessible from the anterior opening described above.

Fig. 644.



Trephine openings for hemorrhage from the meningeal artery: *m*, anterior trunk; *a*, *a*, *a*, its branches; *p*, posterior trunk; *p'* (dotted), abnormal course of same; *I.*, Vogt's trephine opening; *II.*, Krönlein's two openings; *III.*, Witherle's; the two large circles show Steiner's openings. (Steiner.)

Meningocele, Encephalocele, and Hydrencephalocele.—Congenital tumors formed by a hernial protrusion of the membranes and of the brain-substance are most frequently found at the root of the nose and near the posterior fontanelle. When only the membranes protrude, a cystic tumor known as a **meningocele** is formed. (Fig. 645.) These tumors vary from the size of a walnut to that of an orange, and are generally flaccid, although sometimes tense. They fluctuate, and very rarely pulsate with the brain. The skin covering them is thin and sometimes altered into a cicatricial membrane, particularly over the vertex of the tumor. The tumor is frequently translucent. **Encephalocele** exists when brain-tissue is extruded, forming a solid mass, which occupies the centre of the tumor. **Hydrencephalocele** is the term applied to those cases of encephalocele in which the centre of the mass contains a cavity, which sometimes connects with the ventricles and contains fluid. It is supposed that

Fig. 645.

Meningocele. (Graham.)

at some period of the fœtal life the intracerebral tension becomes so great as to force a portion of the brain out of one of the fœtal openings in the skull, this tension being produced by an abnormal secretion of the cerebro-spinal fluid in the ventricles, and an encephalocele results. By the closing of the foramen in the skull, the neck of the protrusion is slowly reduced to a narrow pedicle. In no case is any important brain-substance included in the tumor. In the formation of a meningocele it is supposed that the accumulation of fluid takes place between the brain and the membranes, forcing out only the latter. The frontal meningoceles are sometimes associated with the rare deformity of lateral fissure of the face, and it is possible that the tumor as well as the fissure may be the result of amniotic adhesions or bands, rather than of intracranial pressure.

In extreme cases, and especially in occipital encephalocele, the mass outside of the skull may be as large as the brain within it, and idiocy and early death may follow. In the frontal cases of medium size the individual may reach adult life, and in some cases the brain power may be normal, but cerebral atrophy, epilepsy, and idiocy are the rule. Von Bergmann has pointed out that in many of these cases the skin over the tumor undergoes angiomatous degeneration, so that the mass appears like an ordinary cavernous angioma of unusual size. Although any attempt to remedy this condition is dangerous, the prognosis without operation is so poor that some treatment is generally indicated. When the tumor is very small, pressure has been successful in a very few cases, but removal by an operation similar to that for spina bifida is generally necessary.

Inflammation of the Brain and its Membranes.—Meningitis.—The inflammations of the dura mater are of little surgical interest, although pachymeningitis syphilitica may cause hemorrhage, and some successful operations in such cases are on record. Pachymeningitis may produce adhesions between the brain and the dura mater, demanding surgical interference because of epileptic attacks, severe headache, or localized paralysis. By the term meningitis is generally understood an inflammation of both the pia and the arachnoid, for clinically we cannot distinguish between them. Acute meningitis arises from infection through a compound fracture or other injury to the head, or from suppuration of the middle ear. The inflammation may be limited to a small area or may extend over the entire surface of the brain.

The pathological changes in meningitis are dilatation of the vessels, serous effusion, cellular infiltration, cloudy thickening of the membranes, and the formation of adhesions with the cortex and the dura mater on either side. In the later stages suppuration may occur, the pus collecting in the sulci under the pia or spreading diffusely over the brain, with a tendency to collect at the base. When the disease remains strictly localized, as is frequently the case when the infection takes place from an infected wound or from suppuration of the middle ear, adhesions form which may limit the extension of the pus, as in similar conditions in other serous cavities, and the symptoms are less severe, although they may still be very serious.

Symptoms.—Meningitis is almost always accompanied by some encephalitis, and the surgeon seldom sees it alone: hence the clinical picture

is a compound of the two conditions. The symptoms of meningitis may be divided into a stage of excitement and a stage of paralysis. They begin with headache, gradual rise of temperature, hyperæsthesia of all the senses, especially tenderness of the scalp and photophobia, with gradually increasing restlessness alternating with fits of drowsiness. The pupils are at first contracted and then dilated, being sluggish in either case, and they may be unequal. A chill is rare, and the pulse remains slow. The drowsiness gives way to delirium, and muscular twitchings succeed, with local and general convulsions. Occasionally a localized paralysis is found, even in the first stage (Von Bergmann), and it may be the first symptom of the disease in meningitis of the convexity, but local paralyses are rare in basal meningitis, because the motor centres are situated at the vertex. The symptoms of the first stage are a combination of compression of the brain by the exudate, and of septic poisoning caused by the absorption of the infectious materials. In the second stage the signs of pressure predominate. The drowsiness increases to actual coma. Total paralysis is common in meningitis of the vertex, and the sphincters are paralyzed or so relaxed that the feces and urine may be passed unconsciously. Tonic convulsions also occur. The pulse-rate increases and fever appears, being of the continuous type, or with a morning remission, but just before death the temperature may fall. In meningitis of the base there are no local paralyses, but the inflammation is very apt to extend to the cord, the neck becoming stiff, and Cheyne-Stokes respiration appearing on account of the proximity of the inflammation to the respiratory centre in the medulla.

The **diagnosis** of meningitis is not always easy in the first stage, especially if concussion or compression of the brain is also present and we are dependent upon the rise of temperature to guide us, the nerve symptoms being masked by the general depression of the cerebral functions. The diagnosis from pyæmia may be made by the absence of chills.

Treatment.—The surgical treatment of meningitis is naturally drainage, but it has up to the present been very unsatisfactory because of the adhesions. The operative treatment is practically limited to those cases which originate from infected penetrating wounds of the skull and from suppurative disease of the ear, and if the diagnosis can be made early enough there is a possibility of recovery. Infected wounds must be thoroughly cleansed, sinuses laid open, and free drainage instituted, any necessary amount of bone being cut away. When the infection originates in ear disease the usual opening into the mastoid is made, and if the lesions found there are not sufficient to account for the symptoms, or if the latter continue in spite of the operation, the groove of the lateral sinus should be inspected, and, if no phlebitis is found, the dura may be opened by cutting away the bone upward and the membranes examined.

Tubercular meningitis is the only form of chronic meningitis that is of interest to surgeons. It occasionally forms well-limited foci, giving localizing symptoms and permitting exact diagnosis and surgical treatment, and, even when the disease is general and marked by considerable serous effusion into the ventricles or on the surface of the brain, good results have been obtained by drainage, which relieves the brain of the pressure, at least tempo-

rarily. The lesions of tubercular meningitis consist in the appearance of miliary tubercles scattered through the membranes, and sometimes massed into tumors of considerable size, or forming abscesses surrounded by a cheesy wall, depressing the cortex or invading it by ulceration. In other cases the amount of serous effusion appears to be entirely out of proportion to the gravity of the lesions found, there being no adhesions and but few miliary tubercles. In tuberculous disease the lateral ventricles have been drained (Keen) through that part of the brain where they are nearest to the surface on the side of the head, or by trephining the occipital bone, lifting up the cerebellum, and draining the fourth ventricle just beneath it (Quincke).

Phlebitis of the Sinuses.—The sinuses of the brain are particularly liable to infection because of their intimate connections with the ear, the orbit, and the veins of the skull and scalp, where suppurating processes are so frequent, and it is from these three sources that phlebitis generally originates. The pathological changes are similar to those of phlebitis elsewhere, the endothelium is thickened, there is a deposit of fibrin, and thrombosis sets in. Clots form readily in the slow current, and particles are especially likely to be swept off because of the rigidity of the walls, so that pyæmia is a frequent result of sinus phlebitis. The phlebitis often extends to the veins outside of the head, inflammation of the lateral sinuses especially extending into the internal jugular. **Symptoms.**—When sinus phlebitis complicates suppuration of the ear, the orbit, or some wound of the scalp, in addition to the symptoms of the original condition there appears some sluggishness of cerebral action, perhaps some headache, but mainly a sharp rise of temperature to 103° F. (39.5° C.) or more, with hectic variations, rigors being seldom seen. If the internal jugular is involved, there is tenderness and a little fulness along its course. **Operative treatment** of sinus phlebitis is indicated when the lateral sinus is involved, and the vessel should be exposed by the ordinary mastoid operation and laid open. The jugular vein can be ligated in the neck beyond the seat of infection and opened above the ligature, when irrigation can sometimes be made through the sigmoid sinus and the jugular. These cases are almost invariably fatal, but recovery has followed this treatment.

Encephalitis and Abscess of the Brain.—Encephalitis is a term applied to inflammation of the brain. The older surgeons believed that any injury to the brain might cause inflammation, but the modern doctrine teaches that inflammation can originate only from bacterial infection, and that injury merely produces conditions which are favorable for infection. Thus, a portion of the brain may be contused, or there may be a hemorrhage into it, and if there is a compound fracture in connection with this injury infection readily occurs, and inflammation is easily set up in the tissues, because their vitality has been impaired. It is, of course, possible that infectious agents circulating in the blood might reach such a focus even without any external injury of the head and cause inflammation, but well-authenticated cases of this kind are rare. In the early stages of encephalitis we have the usual changes of inflammation, which are followed by multiplication of the connective-tissue cells and a round-cell infiltration,

the nerve-cells undergoing degeneration. The gross appearances are a manifest softening, at first of a pinkish hue, later dark red or yellow. The inflammatory changes result in the production of pus or the complete softening and degeneration of the nerve-tissues. When an abscess is produced its wall consists of brain-tissue thickly infiltrated with round cells, and no true capsule of connective tissue is formed, so that, although the process may remain stationary for many years, the patient is in constant danger from rupture of the abscess or its further extension. The infection often arises from an infected wound, and in such cases the abscess is apt to be situated in or near the cortex. The presence of a foreign body in the brain renders the liability to infection much greater. Fracture of the base also affords an opportunity for infection, by opening the Eustachian tube or other cavities lined with mucous membrane. The most common source of infection, however, is suppuration of the middle ear, followed by perforation of the tympanum or inflammation of the mastoid, which is apt to cause abscesses in the temporo-sphenoidal lobe. The great majority of these abscesses are situated beneath the cortex in the white substance, and have no direct communication with the source of pus in the ear.

Cerebral abscesses are often the result of pyæmia, but they are also frequently its cause. Metastatic abscesses in the brain are generally multiple and of small size, and they are especially common as the result of chronic suppuration of the pulmonary organs. Abscesses are most common in the temporo-sphenoidal lobe (especially on the right side), and are then usually secondary to ear disease, the frontal and parietal lobes being more apt to be affected by abscesses of traumatic origin, and the occipital lobe by pyæmic abscesses. Otitis may also originate abscesses in the cerebellum. The location of an abscess of the brain can sometimes be determined by the order in which the local symptoms appear, for if they begin in the face and spread to the arm the abscess will lie near the cortical part of the brain, pressing on the motor centres, while the opposite order, beginning in the leg and extending to the face, indicates an accumulation of pus in the central part of the brain, in the internal capsule, where it would press upon the fibres passing from these centres in a reverse order in its extension (Macewen). In abscesses of the frontal and temporo-sphenoidal lobes the eye-symptoms may be diagnostic of the location, paralysis of the third nerve, with internal strabismus and dilated pupil, indicating disease upon the same side as the eye affected.

Symptoms.—In the traumatic cases the encephalitis is generally cortical, and when acute it is almost always associated with meningitis. Encephalitis complicating meningitis may be suspected if the signs of inflammation do not appear at once, and especially if paralytic symptoms affecting the face, the extremities, or the speech are well marked in the early stages. It is very necessary to separate this superficial inflammation with early symptoms from those chronic abscesses deep in the brain which develop at a later date, whether from traumatism or from ear disease, and the latter class includes the greater number of abscesses of the brain. The symptoms of the chronic abscesses are the result of three causes—the septic infection, the general pressure on the brain, and the local pressure.

The first stage of abscess of the brain is often obscure. The temperature is the most reliable symptom, and there may be a slight rise, particularly at night, with chilly sensations, and perhaps an actual chill, the patient also exhibiting signs of mental depression. At a later stage there may be earache, if the trouble be the result of disease of the ear, and headache is one of the most reliable symptoms in all cases. When the temperature rises there is more pain, especially on that side of the head where the abscess lies. If there has been a discharge from the ear, it usually ceases. Vomiting may be present, with or without nausea. One of the characteristic signs of abscess of the brain is the great variation in the symptoms from time to time, and they sometimes completely disappear for an interval of days or weeks.

In the stage of active extension all the symptoms are increased, especially the pain and the mental dulness, the latter resembling the dulness of opium-poisoning, according to Macewen. The patient lies in a drowsy, indifferent state, answers questions very slowly, goes to sleep while in the middle of a sentence, and in attempting any voluntary action shows a decrease of will-power. The temperature is usually 97° F. (36° C.), or ranges between that and 99° F. (37° C.); the pulse is very slow, about 60, or even down to 30, beats a minute. The respiration is natural or slow, but in cerebellar abscesses it may be irregular, with Cheyne-Stokes phenomena; and in the last stages it may be reduced to eleven respirations in the minute, and may cease before the heart stops at the time of death. Vomiting is present, being brought on by sitting up in bed, and convulsions may occur, but the latter are rare in abscesses of the temporo-sphenoidal region. There may be distinct local paralysis. The pupils may be affected, and, as a rule, the pupil on the same side is diminished when the abscess is small and dilated when it grows larger, but in either case it is apt to be sluggish and not to react to light as well as the other side. Authorities vary as to the frequency of choked disk, but the weight of evidence is in favor of the existence of a low grade of optic neuritis in all cases. In the final stage coma may set in or meningitis may develop, the former being due to the increasing pressure of the abscess, the latter to infection or to perforation of the abscess upon the surface of the brain. An immediately fatal accident is the bursting of the abscess into the cavity of the ventricles, shown by the slow pulse becoming suddenly very rapid, the respiration growing shallow or deep and stertorous, and death resulting within twelve hours in convulsions or coma.

Prognosis.—Operation affords the only real opportunity for recovery, although very small abscesses may doubtless remain latent for long periods, and it is possible that they may be absorbed. The destruction of brain-tissue is permanent, and paralysis or epilepsy may result from the adhesions produced by the scar.

Diagnosis.—The diagnosis of abscess of the brain is exceedingly difficult except in simple cases, and even in such cases it may be confused with phlebitis of the sinuses, although in the latter the pupils remain normal unless the cavernous sinus is involved, and the phlebitis may extend into the jugular vein, causing tenderness in the neck and high fever. In tumors of the brain the paralysis is more distinct, the development is slower, and

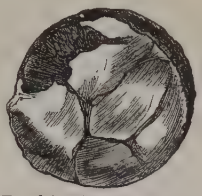
the symptoms are more constant, than in abscess. The greatest difficulty in the diagnosis of abscess is the tendency of the disease to become latent.

Treatment.—In the early stages of an acute encephalitis originating from an infected wound the establishment of thorough antisepsis in the wound and the removal of all sloughs are the first steps in the treatment. Sedatives may be administered, and ice applied over the head. When it is certain that abscess has occurred from traumatism or ear disease, operation should be done as early as it is possible to make the diagnosis. To open the temporo-sphenoidal abscesses we may follow Von Bergmann's rule: "the field of operation is indicated by four lines, the upper limit being a line five centimetres above the zygoma and parallel to it, the posterior limit vertical to the base-line of the skull and situated at the posterior border of the mastoid, the anterior limit a line parallel to the second, drawn through the temporo-maxillary articulation; and the lower border of the opening should be not less than one centimetre from the root of the zygoma." The opening is to be a liberal one, at least three centimetres wide. If no pus is found between the dura and the bone, the dura should be opened. If pus is found outside of the dura, the pus-cavity must be thoroughly cleansed before the dura is incised. If it seems probable that the symptoms are due only to the extradural collection of pus, the dura should be left untouched, but it should be opened if there is absence of pulsation, or if fluctuation can be felt underneath. When the dura is opened we may find a localized collection of pus on the surface of the brain beneath the dura, but this is rare, a deep abscess being the rule. The brain-substance must be explored with the most careful asepsis. It is better to make this exploration with some blunt instrument, like a narrow director, than with an aspirating needle, because the latter may cause troublesome hemorrhage. If pus is obtained, the opening should be enlarged by dilatation and the cavity drained with a tube or wick of gauze. It is unwise to use irrigation.

Epilepsy.—It was formerly supposed that trephining would cure epileptic convulsions by the simple relief of intracranial pressure, but the results were so unsatisfactory that the operation fell into disuse. The modern operations, however, depend upon the exact localization of the lesion and its removal. Epileptic convulsions may be the result of some general condition or of a limited cerebral lesion. When the habit of convulsive attacks has once been formed by a cortical irritation which is only local in its primary effects, the tendency is for the general disease to be developed, and the convulsions continue even after the local cause has been removed. Epileptic convulsions are among the symptoms of various diseases, such as tumors, abscesses, and other conditions, which cause diminution of the space within the skull. They may be the result of peripheral nervous irritation set up by an adherent or painful scar on the head or limbs, and many cures have been produced by the removal of such scars. They are also caused by adhesions between the brain and the membranes, by cicatricial tissue in the brain, or by the pressure of a bony point the result of a depressed fracture. (Fig. 646.) These causes may be divided into two classes, traumatic and pathological. In many cases a clear history of previous injury can be obtained, and a scar or depression is found on the outside of the skull.

General Epilepsy.—The symptoms of general epilepsy are sufficiently described in special text-books, and we need only outline them here. The epileptic convulsion may be preceded by an *aura*, the patient being aware that something is about to happen by some peculiar sensation, but this is often absent. When the attack begins the patient suddenly assumes a rigid position, followed by convulsive movements sometimes limited to one part of the body, sometimes general, and he falls to the floor unconscious, his muscles working without control. The movements continue for several minutes, and gradually cease, but the patient remains unconscious, pale, and occasionally vomits. Gradually he regains consciousness and feels very weak from the strenuous muscular exertion, but he is often unaware that anything has happened. For general epilepsy the surgeon can do nothing.

Fig. 646.



Trephine button from skull of epileptic, showing depression of bone from fracture seventeen years previously. (Agnew.)

Local Epilepsy.—Symptoms.—Local convulsions, or so-called Jacksonian epilepsy, may be confined to twitchings of the muscles of one finger or toe or of one part of the face, but, as a rule, an attack which begins in this extremely limited way spreads to adjoining muscles, gradually advancing up the arm or leg to the face, or in the opposite direction. After this gradual advance or "march" of the spasm a general convulsion with loss of consciousness may follow exactly like that of general epilepsy, such attacks being sometimes given the name of "focal" epilepsy, while those without loss of consciousness and with limited spasms are called true Jacksonian epilepsy. The limited spasms are due to the fact that the cause of irritation is situated directly over the motor centres and bears most severely on a limited point, the excitement spreading like a wave in regular succession from this centre to those adjoining it.

Prognosis.—The progress of the disease is invariably from bad to worse, although the course may be very slow. The success of any operation depends upon its performance before the epileptic habit is formed and upon the possibility of removing the exciting cause.

Diagnosis.—Convulsions due to uræmia and chronic cerebral lead poisoning must be excluded by the absence of indications of renal disease and of lead in the tissues or urine. The diagnosis of epilepsy depends upon the exclusion of tumors and abscesses. When it has been decided that the epilepsy is due to a local lesion, the exact situation of the latter is to be sought for; if that can be determined, an exploratory operation is indicated, even if the nature of the lesion cannot be ascertained.

Treatment.—A scar on the scalp or on the surface of the bone may assist in the localization, but scars are often the result of falls in the fits, and not of the original injury. If no marks are found, the skull is opened and a search made for adhesions, tumors, or other causes of irritation of the brain. Even when nothing whatever can be found, if the attacks have been strictly Jacksonian in character it is allowable to excise the cortical centre of the part in which the attack has usually begun, the motor centre for the upper extremity being entirely removed when the attack begins in the fingers, for

instance. Horsley advises the excision of the centre in every case, even when some irritating cause has been found and removed, such as the projecting bone in an old depressed fracture, in order to get rid of a part of the brain which may have already formed the epileptic habit. Paralysis ensues in the parts supplied by the centre removed, but the paralysis is temporary, and in a few weeks the function is restored. The results of these operations for epilepsy, of which many hundreds have been performed, are decidedly unsatisfactory; but the condition is a hopeless one, and even a respite of a few months will repay the patient for the suffering.

Hydrocephalus.—Hydrocephalus is the distention of the ventricles by cerebro-spinal fluid caused by the obstruction of the passages through which the fluid escapes, to an interference with the venous circulation of the pampiniform plexus, or to a tubercular infection. It occurs almost invariably in children, the child's head becoming very large, the fontanelles remaining open, the sutures widely separating and leaving the membranes pulsating between the edges of the bones. The frontal bones are particularly distended, and the forehead projects beyond the eyebrows. The general symptoms are mental irritability, with headache, strabismus, optic neuritis, vomiting, vertigo, and slow pulse, especially after the sutures have become ossified. There is often in the early stages a certain precocity, but later the cerebral faculties are decidedly impaired. Convulsions are sometimes seen.

Treatment.—Attempts to cure hydrocephalus by aspiration were made many years ago. Keen has recommended direct drainage through the parietal bones at the point where the ventricles lie nearest the surface, one and a half inches behind the external auditory meatus and the same distance above the base-line of the skull, the trocar being directed upward. Quincke recommends drainage by tapping the spinal canal below and applying pressure to the head at the same time. It has also been suggested by Parkin to drain by tapping the subarachnoid space by trephining the occiput and lifting up the cerebellum. Some favorable results have been obtained in these cases, but, as a rule, the treatment secures only temporary improvement.

Microcephalus.—Idiotic individuals often have small heads, and the theory has been advanced that the premature ossification of the sutures prevents the proper development of the brain, but it is incorrect, for the sutures do not ossify earlier in idiotic than in normal children.

Treatment.—The operation of *craniectomy*, which is intended to give the brain an opportunity to expand, has been performed on a large number of cases, but without much success in improving the mental condition. A strip of bone one-quarter of an inch wide, including the entire thickness of the skull, is removed on one side of the longitudinal sinus, and oblique strips are also cut from the parietal bones. A small trephine is applied, and entering the cutting forceps by this opening the strip is removed. With the aid of an electro-motor saw, such as Powell's, these operations can be done with great rapidity.

Intracranial Tumors.—Pathology.—Whether an intracranial tumor grows from the bones of the skull, from the membranes, or from the brain itself, the chief effects produced by it are mechanical and due to its mere presence within the cranial cavity. The clinical history of the different

varieties is very similar, except that the more rapid growth of malignant tumors intensifies the symptoms, and they are liable to recur after a successful removal by operation. The dura mater is subject to sarcomata and to fibrous growths, but unless the malignant tumors penetrate the skull and appear externally, as they are apt to do, it is impossible to distinguish neoplasms in this situation from growths originating in the brain. In the latter organ the most common malignant tumors are those secondary to malignant tumors elsewhere.

Primary intracranial tumors are rare, the most common being sarcoma, glioma, and fibroma. Tuberculous and syphilitic granulation masses are more common in the brain than true neoplasms (twenty-five to fifty per cent. of cerebral tumors being tubercular) and cause similar symptoms. Both tubercle and syphilis are usually associated with similar lesions elsewhere in the body, and the diagnosis is made from this clue. The tuberculous masses are generally multiple, and therefore occasion a great variety of symptoms, but in rare instances there may be but one. Hydatid cysts of the brain are extremely rare in America. The cysts usually found are due to degeneration of tumors or are the result of cerebral hemorrhage. In adults cerebral tumors are most frequently situated in the cortex, while in children they occupy the central part of the brain or the cerebellum. They may be minute or may fill one-quarter of the cranial cavity.

Symptoms.—The symptoms of those tumors which are within the reach of the surgeon depend upon cerebral pressure, causing irritation, followed by paralysis. Mental disturbance, or at least somnolence and indifference, are found in one-half of the cases. The patient falls asleep while talking, is very slow in answering questions, loses his mental power and memory, and is unable to apply himself to any occupation. Vertigo, nausea, and vomiting are present in a large proportion of cases, and are especially marked in cerebellar tumors. Headache is a very constant symptom, and may be associated with tenderness of the skull over the tumor. The pupils are sluggish in reacting to light, contracted at first, then widely dilated, especially on the affected side. Choked disk is almost invariable. The nerve symptoms are a combination of irritation and paralysis, for a tumor pressing slightly upon the nerve-centres irritates them, and as the pressure increases or the disease involves the centres themselves it suspends or destroys their functions, the first stage being shown by convulsions, the second by paralysis if the motor centres are involved. Convulsions are present in about one-quarter of the cases, and may be limited at first, or general from the beginning. Typical Jacksonian convulsions are seen in some tumors of the base as well as in those of the cortex. The paralysis may be local or there may be hemiplegia, and it may be so slight as to be detected only by a careful examination. The symptoms are constant and progressive, unless the tumor is very vascular, when alterations in the blood-pressure may cause variations in its symptoms. External perforation takes place in a small percentage of cases. Death is the inevitable termination.

Diagnosis.—Tumors of the base of the brain are by far the most frequent, and are recognized by their definite symptoms, such as divergent strabismus, conjugate deviation of the eyes, and paralysis of the third, fifth,

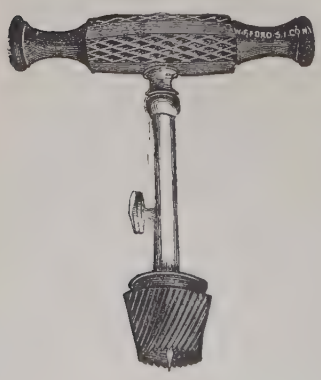
sixth, seventh, and twelfth nerves without any preceding signs of irritation. Anæsthesia is common, and hemiplegia may be accompanied by rigidity, while convulsions are comparatively rare. There may be symptoms of compression, due to acute hydrocephalus. It is impossible to distinguish between tumors of the cortex and those just below it in the centrum ovale and the ventricles. The exact situation of a tumor near the cortex may be determined when it involves one of the well-known motor centres, by aphasia if the lesion is on the left side, and sometimes by partial anæsthesia. In the occipital region hemianopsia may be present. Tumors of the temporosphenoidal lobe have no local symptoms, except occasionally word-deafness. A tumor in the cerebellum (which is generally tubercular) may be suspected when the symptoms develop very rapidly, with a staggering gait.

Treatment.—Removal by operation is the only possible treatment for tumors of the brain, with the exception of gumma, and even gumma should be removed when it proves obstinate to the usual remedies. Of six hundred cases of intracranial tumors only six per cent. were found suitable for operation by Starr, and other observers agree as to this percentage. An early recurrence makes operation useless for tuberculous tumors, as was the case in a solitary tubercular mass of large size removed by us. In cases of doubt as to the existence of syphilis, antisyphilitic treatment may be given for from six to eight weeks, but only when the patient's general condition remains so satisfactory that the time can be spared.

An opening is made in the skull, preferably by the osteoplastic flap method, and the tumor removed, after ligation of the vessels which supply it, by ligatures passed around them in the cerebral tissue with needles. Œdema of the brain is common after the removal of tumors, but may be prevented by absolute asepsis and the maintenance of pressure. The mortality of these operations appears to be about thirty per cent.

The General Technique of Operations upon the Skull and Brain.—The entire scalp should be shaved, if the brain is to be exposed, and sterilized in the usual way. During all operations on the skull the patient's head should be elevated, in order to lessen the hemorrhage.

Fig. 647.



Trephine.

Trephining.—The pin of the trephine is set so as to project slightly and made to penetrate the bone. When the crown of the trephine touches the bone it should be made to cut evenly into the latter on all sides by regular rotation, and when a groove has been cut the pin should be withdrawn. (Fig. 647.) The crown is then made to saw slowly through the bone until the diploe is divided and the inner table reached, which will be evident from the greater resistance of the latter. The groove is then very slowly deepened, and the bottom of it tested from time to time by a needle or the flat end of a probe, to determine when the bone has been completely divided. If the latter is divided first on one side, the crown must be slightly tilted in the opposite direction,

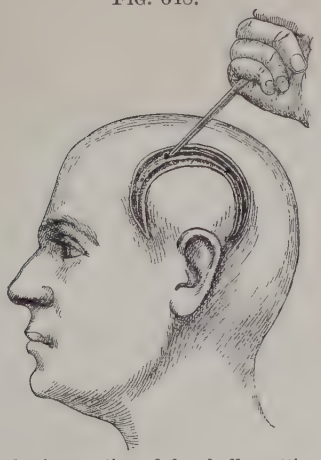
so as to avoid injury to the dura while dividing the remaining bone. The central portion of bone, known as the button, is to be removed by prying it out of place.

In operating with the ordinary trephine for tumors or abscesses, which require large openings in the skull, a crown one and a half or two inches in diameter is used, and the opening may be enlarged by the rongeur or chisel.

Depressed Bone.—In cases of compound fracture a wound is already present, and it is only necessary to enlarge it in the most suitable directions to make a flap. Loose fragments are easily raised, and impacted fragments may be released by cutting away the bone with the chisel or rongeur. If the impaction is very great the trephine should be applied with a part of its circle projecting over the edge of the fractured bone. When a depressed fracture exists, without any external wound, a flap must be cut so as to expose the point of fracture. As a rule, in operations upon the skull flaps are made of a horseshoe or rectangular shape, with the base below. The pericranium is stripped from the bone with the flap.

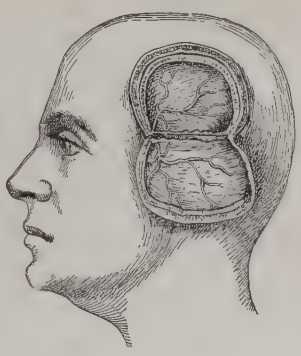
Osteoplastic Flap.—The osteoplastic method of Wagner-Wolff is performed as follows. A horseshoe-shaped incision is made, and the edges are allowed to retract. A groove is then cut in the bone following the line to which the skin of the flap has retracted. (Fig. 648.) This groove may be cut with a chisel or with a circular saw run by an electro-motor, and should be oblique, so that the outer table of the

Fig. 648.



Osteoplastic resection of the skull: cutting the bone-flap with a chisel. (After Treves.)

Fig. 649.



Osteoplastic resection of the skull: flap turned down, exposing dura mater. (After Treves.)

flap shall rest on the inner table of the skull when the bone-flap is turned back into place. The bone is then cut partly through under the base of the flap as far as possible with the chisel without disturbing the soft parts any more than is necessary, and the remaining bone at the base is broken and the flap turned back, the scalp acting as a hinge. (Fig. 649.) By this method the gap made in the skull can be closed after the operation.

Hemorrhage from the Bone.—Hemorrhage from the veins of the diploe can be controlled by pressure, by breaking in the bone around the opening with a blunt-pointed instrument, by stuffing a little catgut into the

bleeding vessel, or by filling the open vessels with a mixture of sterilized shoemaker's wax and paraffin (Horsley). (See page 327.)

The Brain.—When the dura is incised it should be opened by a semicircular flap, and not by a crucial incision. If it is necessary to divide the cortex or to remove a part of it (for epilepsy, for instance), the vessels must first be secured by fine ligatures passed around them by blunt-pointed curved needles. If one of the sinuses is wounded, hemorrhage may be controlled by suture of the wall or by simple pressure with gauze, the end of the latter being brought out of the wound. When the normal brain is exposed it usually bulges into the opening and pulsates, unless the heart-action is feeble. Unusual protrusion indicates pressure by a tumor, a clot, or an abscess, and lack of pulsation shows that the tumor, blood, or pus is close to the opening in the skull. In exploration for pus or fluid a blunt instrument like a small director is to be preferred to an aspirating-needle, as the latter is apt to provoke troublesome hemorrhage. The various motor centres can be accurately located by touching them with a double-ended sterilized electrode through which a very weak current is passed, and observing the muscles affected. A tumor may be recognized by the hard resistance felt in the depth, and a cyst or an abscess may give a sense of fluctuation. An encapsulated tumor may be shelled out with the fingers or blunt instruments, but this is to be done cautiously, because it is impossible to control any bleeding from the bottom of such a wound by ligatures. If there is much hemorrhage after the removal of the tumor, the wound may be packed. A strip of gauze is to be placed in the bottom of the cavity and the end led out through the opening, a second strip is placed next to the first, and so on, the end of every strip being carried down to the bottom. Firm pressure is then applied by a dressing. Quite severe hemorrhage may be controlled in this way without producing symptoms of compression, if the gauze is properly inserted.

Closing the Wound.—If there is no oozing, the wound may be closed, the dural flap being turned down and secured by interrupted or continuous sutures if there is not too much tension. If the dura has been removed, pieces of rubber tissue, gold-leaf, or celluloid have been inserted with success to prevent the formation of too strong adhesions between the brain and the bone or the skin-flap. Keen has suggested that a flap of pericranium be dissected up and inverted into the wound, with the bone-producing side uppermost. If there seems to be oozing, or if there is any likelihood of retention of secretions, a small drain should be inserted. If a bone-flap has been formed, it may be returned to its place and secured by sutures; if a trephine button has been removed and loose fragments have been taken from the edge, they may be replaced, the large button being broken into pieces about half an inch square. The bone should be placed in warm sterilized salt solution immediately on removal if it is intended to replace it.

If the hemorrhage or shock of exposing and exploring the brain threatens to be too great, the wound may be closed and the operation resumed a few days later.

Removal of the Gasserian Ganglion.—This ganglion may be removed by the osteoplastic operation, as suggested by Hartley and Krause.

A horseshoe-shaped osteoplastic flap is made in the temporal region with its base at the zygoma. A little more of the bone at the base of the skull is gnawed away with rongeurs, and then, while the bone-flap is strongly retracted and turned down towards the cheek, and the brain covered by the uninjured dura is drawn inward by a very broad retractor, the Gasserian ganglion is seen at the bottom of the wound. The ganglion is to be seized with strong forceps after being separated by blunt dissection, the second and third divisions of the nerve cut across as close as possible to the foramina of exit, and the central nerve-root and the first division slowly twisted out by rotating the forceps. The mortality from this operation is still high (ten per cent.), on account of its difficulties and the feeble state of the patients, but the results as to a permanent cure promise to be excellent.

Localization.—The recent advances in brain surgery have all depended upon the introduction of strict asepsis, which reduces the danger of the operations, and upon the established facts of localization, which enable us to determine the exact site of the various lesions. The doctrine of localization is briefly this. Each function of the brain is carried on by some particular part, called a centre, and the removal or destruction by disease of any centre causes the loss of the corresponding function. It is possible in some cases for other parts of the brain to take up the work of certain centres when destroyed, but this substitution is so slow and imperfect that it can be disregarded in making a diagnosis. The centre for speech, for example, is usually situated on the left side of the head in right-handed persons, and an injury upon that side of the head appears sufficient to produce complete aphasia, which may remain permanently in some persons, but in the majority the power of speech returns after an interval, because of the education of the similar part of the brain on the other side.

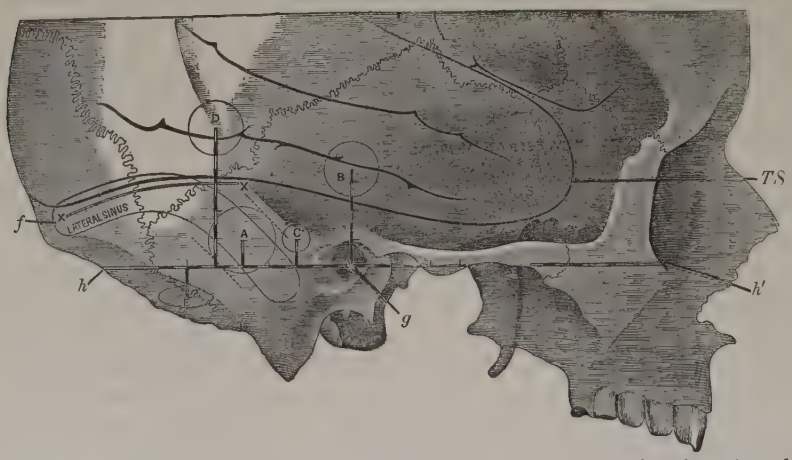
The chief motor centres are shown in Fig. 653 as they lie clustered about the fissure of Rolando, those of the leg being near the vertex, and those of the arm and the face lower down. Their position may be defined by certain external landmarks. Technical names have been given to certain points upon the skull, such as the *nasion*, the junction of the nasal and frontal bones; the *glabella*, the protuberance just above the root of the nose; the *inion*, the occipital protuberance; the *pterion*, the meeting point of the sphenoid with the frontal, parietal, and temporal bones; the *bregma*, the junction of the sagittal and coronal sutures; the *stephanion*, where the temporal ridge crosses the coronal suture; the *asterion*, the meeting point of the parietal, occipital, and temporal bones; and the *lambda*, the junction of the sagittal and lambdoid sutures.

Reid's base-line, which is used in certain measurements, is a line indicated by a plane passing through the infra-orbital ridge and the centre of the external auditory meatus on either side of the head and continued backward towards the occiput. (Fig. 650, *h*, *h'*.) The transverse fissure lies just above this plane across the back of the head.

To find the **fissure of Rolando** (Thane-Hare), the distance from the glabella to the inion is measured, and .557 of this distance measured backward from the point of the glabella will mark the upper end of the fissure of Rolando. In most skulls this is half an inch behind the middle point of

the measured line. The fissure runs forward, making an angle of sixty-seven degrees with the middle line (Fig. 653), and this angle can be laid off by the use of the cyrtometer, which is a strip of flexible metal marked

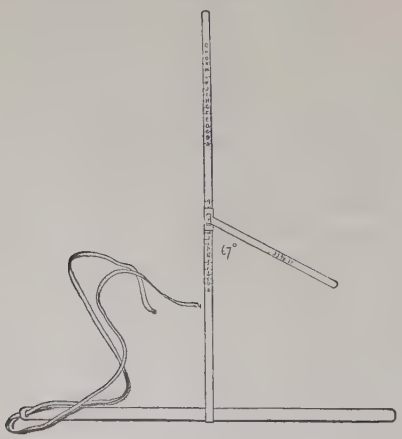
Fig. 650.



External guides to the lateral sinus, etc. From the *Lancet*, in Sajous's "Annual of the Universal Medical Sciences." *g**, external auditory meatus; *h*, *h'*, Reid's base-line marked in one-eighth inch spaces; *x*, *x*, level of tentorium; *f*, lateral sinus; *TS*, anterior end of the temporo-sphenoidal lobe. Trephine openings: *A*, for lateral sinus; *B*, to explore roof of tympanum; *C*, for mastoid antrum; *D*, for temporo-sphenoidal abscess; *E*, for cerebellar abscess.

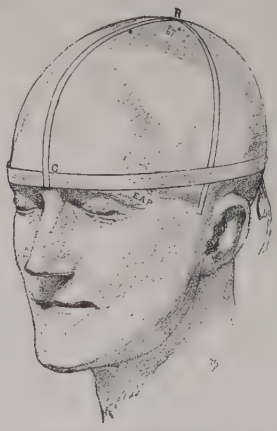
with a scale of inches or centimetres and having a similar strip fixed at an angle of sixty-seven degrees. (Figs. 651 and 652.) Reid has given an easy practical way of finding the angle of sixty-seven degrees for the fissure of Rolando. If a piece of paper is cut with an angle of ninety degrees,

Fig. 651.



Wilson's cyrtometer. (Bramwell.)

Fig. 652.



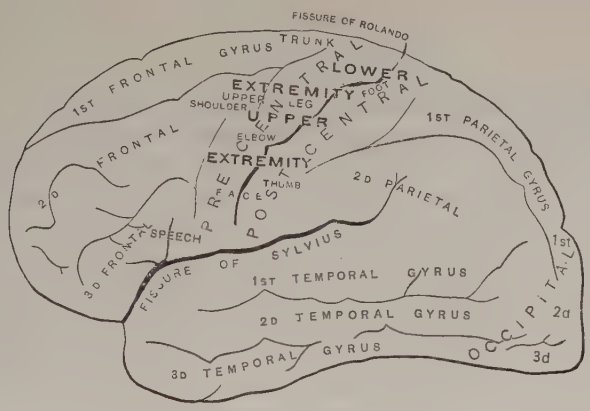
Wilson's cyrtometer applied. (Bramwell.)

and folded so that the two sides of the right angle lie together and the crease runs straight to the point, each of these angles will measure forty-five degrees. One side of the paper is then doubled again, so that its edge lies

parallel to the folded edge, forming an angle of twenty-two and a half degrees. The first doubling is then unfolded, and the sum of the larger plus one of the smaller triangles makes sixty-seven and a half degrees ($45 + 22\frac{1}{2} = 67\frac{1}{2}$), which is near enough for practical purposes.

The **motor centres** lie grouped about the fissure of Rolando as indicated in Fig. 653. To find the **fissure of Sylvius** (Fig. 653) Dana gives the rule:

Fig. 653.



Cerebral localization.

imagine a vertical line from the stephanion to the middle of the zygoma, and then a horizontal line from the external angular process to the highest part of the squamous suture. The point of junction of these two lines will be the beginning of the fissure of Sylvius, and the vertical line will indicate nearly the position of the anterior or vertical branch of the fissure. The motor centre of speech lies just in front of the vertical branch of the fissure. (Fig. 653.) The **temporal lobe**, of which the fissure of Sylvius is the anterior or upper boundary, extends nearly as far forward as the posterior edge of the orbital process of the malar bone. (Fig. 650, *TS.*) The parieto-occipital fissure, or upper border of the occipital lobe, lies just above the lambda. The lower border of the temporal lobe corresponds to a line drawn from a point twelve millimetres above the zygoma and the external auditory meatus to the asterion (Dana). The temporal lobe is about four centimetres wide at the external auditory meatus, and, according to Von Bergmann, a trephine applied half an inch above the meatus would enter the lower part of the lobe. (Fig. 650, *B.*) The middle meningeal artery follows nearly the course of the squamous suture anteriorly, and its anterior branch is given off at the pterion. (See page 714.)

CHAPTER XXV.

INJURIES AND SURGICAL DISEASES OF THE FACE.

INJURIES.

Incised wounds of the face bleed freely, but heal very rapidly, leaving, as a rule, smooth scars. Even a small scar of the face should be avoided, on account of the disfigurement it causes, and therefore every incised wound should be rendered aseptic and closed with sutures. **Contused and lacerated** wounds may also be sutured, for the great vascularity of the skin of the face enables it to live even when severely contused or stripped up in thin flaps. Contusions of the face are marked by the formation of a considerable hæmatoma, with œdema, and ecchymosis, especially about the eyelids. **Foreign bodies** should be carefully removed from the wounds, for wounds of the face are particularly liable to reflex irritation on account of the abundant nerve-supply, and painful scars and even epileptic attacks are not uncommon in consequence of neglected foreign bodies. Occasionally a foreign body becomes impacted in the tissues, and the wound refuses to heal until it has been extracted. Wounds of the cheek may involve the parotid duct and result in a salivary fistula.

Treatment.—Accurate apposition is important in facial wounds, hence the vermilion border of the lip should be accurately maintained, the cartilages and the skin of the nose must be carefully brought into place, and sutures should be so placed as to prevent inversion of the thin edges of the eyelid. Very fine silk sutures are to be introduced close together by fine needles, and they should be removed on the fourth day if the wound is aseptic and there is no tension, in order to avoid a scar.

Burns of the face are very common, sometimes leaving disfiguring scars, and therefore they should be treated in the stage of granulation by Thiersch's skin-grafts. Plastic operations are frequently necessary on account of the later contraction of these scars, and especially to correct eversion of the eyelids.

INFLAMMATIONS.

Dermatitis of the face often occasions great œdema of the eyelid, and conjunctivitis is frequently associated with it. **Furuncles** are especially common on the upper lip and in the nose, especially on the septum. They are serious affections because of the close connection between the facial veins and the sinuses of the brain by way of the veins of the orbit, and if phlebitis begins in the face it may travel backward and involve the brain, with fatal results. Furuncles in this situation therefore should be incised very early, before suppuration occurs. **Anthrax** is quite common on the face, and many cases of supposed carbuncle are due to this infection.

Cellulitis and **erysipelas** of the face are frequent, but the cellulitis is usually limited. Erysipelas occurs in two forms, the superficial or so-called idiopathic form, which develops apparently without any primary lesion, and the suppurative form, in which the infection involves the subcutaneous tissue as well as the skin. The idiopathic form is usually not very serious, spreading slowly, causing no great constitutional disturbance, and sometimes being limited to a very small part of the face and head. It is a very treacherous disease, however, as at any time cerebral complications may develop, so that even the lightest cases need careful watching.

Abscesses of the face are due to the infection of fresh wounds, to suppurative processes beginning in the bones and extending into the subcutaneous tissue, and to infection and suppuration of the lymphatic glands or the parotid glands. The lymphatic glands of the face are not numerous, and the most important are situated (1) in the depth of the cheek near the mucous membrane of the mouth, (2) near the course of the facial artery just above the border of the lower jaw, and (3) just in front of the ear over the facial nerve. The last-mentioned gland is generally affected in inflammations about the ear. The gland at the border of the lower jaw is not infrequently enlarged secondary to cancer of the lip.

Treatment.—The lines of incision for abscesses and inflammatory conditions should be planned to correspond with the natural lines and folds of the face, so as to cause as little disfigurement as possible. They should also be so placed as to avoid injury to the branches of the facial nerve and to Steno's duct.

Ostitis.—Inflammation of the bones of the face is exceedingly common, particularly in the jaws, on account of infection from diseased teeth. The bones of the nose are frequently the seat of necrosis as the result of **syphilis.** A periostitis may be caused by infection from an ulcer in the early stages, or a gumma may attack either the periosteum or the bone itself in the tertiary period. In the first place there will be an acute inflammatory condition, with the formation of abscesses and sequestra, but in the second the bone may be absorbed and disappear in the course of a chronic purulent discharge from the nose with only slight external signs. Hereditary syphilis affects the bones like the tertiary form. The **treatment** of ostitis here is the same as elsewhere—early incision of abscesses, removal of sequestra, and curetting of softened bone.

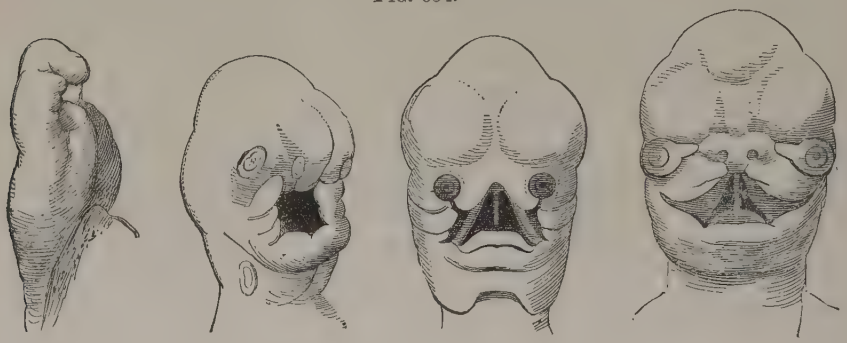
That peculiar variety of tetanus known as **facial tetanus** should be borne in mind in connection with wounds of the face. (See page 66.)

CONGENITAL DEFORMITIES.

Etiology.—In considering the congenital deformities of the face we must bear in mind the development of the parts in the early period of fœtal life, in which a central process grows downward from the frontal bone, forming the bridge of the nose, and two lateral processes also descend on each side of the central one and form the sides of the nose, while from the sides of the head shoot forward two processes which go to form the upper jaws. (Fig. 654.) The vomer grows downward behind the nasal process from the frontal bone, forming the septum of the nose, and at its end it carries

a small bone known as the intermaxillary bone (Fig. 655), in which the incisor teeth develop. This small bone often projects far beyond the line of the gums, and adds greatly to the difficulty of any plastic operation under-

Fig. 654.



Development of the fœtal face. (Coste.)

taken to correct the deformity. The upper lip is formed of three parts, the lateral being supplied by the processes of the upper jaw, and the central part, or philtrum, growing from the vomer and the intermaxillary bone. Thus the cleft of hare-lip is always either on one side or on both, but never in the centre. (Fig. 656.)

The etiology of congenital deformities is not fully understood. In a certain small number of cases heredity seems to be active, but children with hare-lip and cleft palate often come from perfectly healthy parents in whose families nothing of the kind has been known, and, conversely, many individuals with hare-lip have perfectly well-formed offspring. The most generally received theories are the hypothesis of arrested development from unknown causes, and that of the mechanical prevention of development by amniotic bands and adhesions. Amniotic bands may become interposed in a cleft and prevent union of its sides, or they may lie across one of the processes and hinder its growth to normal size and its union with its fellow, or they may be adherent to the process and to some other part of the fœtus and by their traction prevent the growth of the former. Finally, broad adhesions may form between the amnion and any part of the fœtus, and thus check the growth of the latter.

Fig. 655.

Double cleft palate with intermaxillary bone attached to vomer. (From Agnew.)

Hare-lip.—The commonest of the congenital deformities of the face is hare-lip (Fig. 656), by which is understood a cleft of the upper lip. It may be only a notch on the red border, may extend half-way through the lip, or may be complete; and in about one-half the cases it is associated with cleft palate. There may be a cleft on one side only, or one on each side. (Fig. 657.) In very extensive hare-lip and cleft palate there may be an absence of the central part of the lip with the intermaxillary bone and part of the vomer, so that the cleft appears to be median, but it is really a

bilateral cleft with absence of the central piece. Congenital median clefts have been observed in the upper lip in very rare instances, due to fissure of the central part, but they are usually a slight furrow or a sinus. Hare-lip occurs in one case in 2400 of the newly born.

The **prognosis** of this deformity, if cleft palate coexist, is rather serious. In these cases the passage from the nose to the mouth is left open, and the child is very liable to respiratory diseases, because the air enters through

Fig. 656.

Single hare-lip.

Fig. 657.

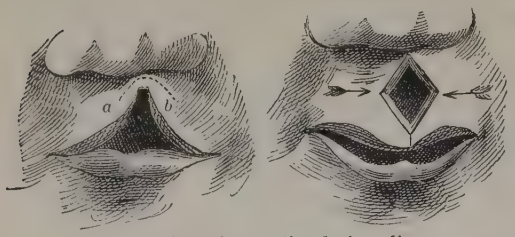
Double hare-lip with cleft palate, showing intermaxillary bone.

this gap instead of being filtered through the nose. The children also swallow badly, and foreign bodies, such as food, easily find their way into the lungs, causing infectious pneumonia. For this reason operation should be done early, usually at the age of about three months, but in strong infants it may be performed earlier.

Treatment.—All the many operations suggested for hare-lip consist in freshening the sides of the cleft and bringing them together. Some operators take off only the border of the cleft, while others cut away the entire central piece, even in the unilateral cases, claiming that in this way they get a more symmetrical union with the scar in the middle line. But the operations most frequently employed are three or four in number. In very slight cases, with only a notch in the vermilion border, the method of **Nélaton** may be selected. A Λ-shaped incision is made above the cleft in the lip, the apex of the cleft is seized with forceps and drawn down, and the ends of the incision (*a*, *b*, Fig. 658) are sutured across the gap, so that the transverse angular line becomes a vertical straight one. The little teat of mucous membrane made by drawing the flap down is left projecting at the edge, and is taken up afterwards by the contraction of the scar. The method most commonly useful is the operation of **Mirault**, in which one side of the cleft is freshened (*ab*, Fig. 659), but on the other side a small flap is cut (*cd*) with its base below. The flap (*cd*) is drawn down and across to the other side (the apex *c* being united to *b*), and the sutures in-

serted. If cicatricial contraction takes place, it simply tends to straighten out the angle in the line of the wound, and does not produce a notch at the point of union in the vermilion border. The operation of **Hagedorn** is about the same in principle as that of Mirault, but all the angles and ends

Fig. 658.



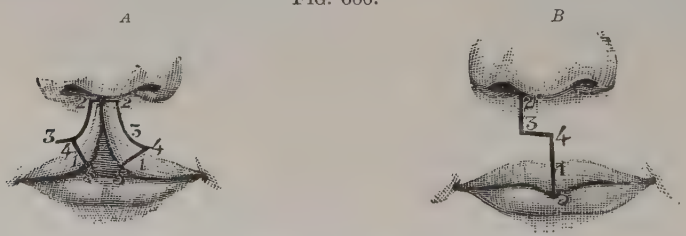
Nélaton's operation for hare-lip.

Fig. 659.

Mirault's operation for hare-lip.

of the incisions are made right angles. It will be best understood by means of Fig. 660, in which the incisions are marked in *A*, and the figures indicate the parts to be brought in apposition to produce the result shown in *B*. In certain cases the operation of **Giraldès** will be most useful. (Fig. 661.)

Fig. 660.

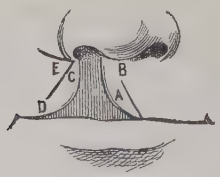


Hagedorn's operation for hare-lip. (After König.)

The incisions being made as indicated, three flaps are formed, *AB*, *CD*, and *E*. *AB* is turned up, *CD* is drawn down, and *E* is drawn towards the middle line. *AB* is then sutured across under the nostril to the upper side of *E*. *CD* and the under side of *E* are united to the raw surface left by turning up *AB*.

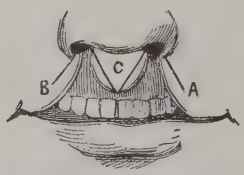
In the majority of cases it will be necessary to separate freely the attach-

Fig. 661.



Giraldès's operation for hare-lip.

Fig. 662.



Operation for double hare-lip.

ment of the lips to the gums, in order to relieve the tension and allow of easy adjustment of the two parts. If necessary, the cheeks may be dissected up from the jaws. When the intermaxillary bone projects in the cleft it may be

cut off, but a better method is to split the mucous membrane along the lower edge of the vomer and detach the membrane on each side, then to excise a triangular piece of the cartilage, which will allow the projecting bone to be forced back into line. The edges of the central part of the lip are to be pared. (Fig. 662.) The lip is united by deep sutures of heavy silk or silk-worm-gut, which should be passed through its entire thickness except the mucous membrane, and by finer silk sutures through the skin and mucous membrane only, care being taken to adjust the vermilion border accurately. When there is great tension, hare-lip pins may be necessary, which are introduced like the deep sutures, and the wound is then drawn together by twisting a sterilized thread in figure-of-eight turns over the ends of each pin.

Other clefts occur in the face. A **lateral cleft** may exist at the ala of the nose where it joins the cheek, or between the lateral frontal projection and the projection which makes the upper jaw. The first of these lateral clefts is necessarily small, but the second may be very extensive, for in early fœtal life the eye is found at the upper outward angle of this cleft, and the deformity may extend up to the eye or even farther. A lateral cleft is also seen at the angle of the mouth, producing the condition known as macrostoma, in which the mouth is abnormally large, extending sometimes as far back as the ramus of the jaw. **Clefts in the lower lip** are extremely rare, and are often associated with a cleft in the lower jaw and even in the tongue. A **delayed closure** of any of the fœtal clefts occasionally takes place, producing an unsightly scar indicating the line of the fissure. Sometimes there is an over-production of tissue in the lines of the clefts, especially at the angles of their junction, and small fibrous nodules or pigmented nævi are formed. The nodules are known as **congenital tubercles**, and are most frequent at the root of the nose and in the centre of the cheek. In other cases a **sinus** or **dimple** may be left, and in the lower lip a double sinus is occasionally seen, with two minute openings symmetrically placed.

Such deformities as absence of an eye or of the nose, or congenital closure of the eyelids or of one nostril, or too great narrowing of the mouth (microstoma), are found, but they are very rare.

Tumors.—Nearly all varieties of tumors are found in the face. **Fibromata** are seen in the skin as small, hard nodules or moderately soft tumors. They should not be confounded with congenital tubercles. They may form large flat moles, pigmented, and covered with hair—the so-called hairy nævus. (Fig. 663.) These disfiguring patches are congenital, and if very large cannot be treated with success. The smaller moles may be excised. They are liable to malignant degeneration. In some cases a soft fibromatous change in the skin produces large pendulous masses, which hang from the forehead, draw the eye out of place, displace the nose by pressure, distort the mouth by the swelling of the lips, and even change the shape of the bones of the skull

Fig. 663.

Hairy nævus of the face. (Case of Dr. Robert Abbe.)

by their traction. These tumors are generally congenital, or originate very early in life. **Lipoma** occurs on the face, although it is not very common. On the forehead it may be congenital, and in such cases lies under the fascia or the pericranium, and has a depression in the skull beneath it, like the dermoids. Lipoma is frequently combined with angioma. **Osteomata** are not uncommon, and are seen in the shape of small and very dense nodules on the frontal bone and on the jaws. They also occur in the nose and the adjoining sinuses, as described elsewhere. **Chondroma** grows from the various bones of the face, and usually ossifies, but it is also found as a part of the so-called mixed tumors which are so common in the parotid gland. Mixed tumors more rarely appear in the substance of the lip, where they form hard, nodular masses, growing very slowly, but with a strong tendency to return after removal.

Angioma is one of the commonest of the tumors of the face, existing in all varieties from a mere telangiectasis to a cavernous mass. The tumors may be pedunculated and globular in shape, sometimes hanging from the end of the nose and attaining a considerable size. On the forehead angioma forms, as a rule, a small tumor; in the cheek and lips, however, it may involve their entire thickness and affect the mucous membrane. (Fig. 664.) It often attacks the muscles in these situations, their capillaries being degenerated, so that a thorough removal necessitates a very extensive operation. The most suitable mode of treatment of angioma of the face is excision when the tumor is small and the wound can be neatly brought together, placing the scar in a situation where it will not be noticeable. In other cases the neoplasm must be treated by multiple puncture with a red-hot needle or by electrolysis. (See page 104.) **Lymphatic tumors** are found in two forms: first, as an encapsulated **lymphangioma**; secondly, as a general dilatation resembling **elephantiasis**, which is liable to affect the lips, producing the condition known as *macrocheilia*. Lymphangioma sometimes becomes **cystic**, the cavities continually growing larger and the walls between them breaking down until a single large cyst is produced, occasionally with little trace of angiomatous tissue around it.

FIG. 664.

Angioma of the lip.

Papillomata are quite common in the skin of the face, but the little tumors do not differ from warts in other situations, except that they should be very carefully watched for fear of a change into epithelioma. **Adenoma** of the skin originating in the sebaceous or sweat glands is not infrequent, forming small tumors, and occasionally masses of considerable size. It also originates in the mucous glands of the lip, and is apt to be cystic. **Mixed tumors** resembling those of common occurrence in the parotid are found also in the lip and cheek. **Sarcoma** is rare in the face except as it originates in the various bones, in the salivary glands, or in the contents of the orbit.

Carcinoma is one of the most frequent tumors of the face, certainly the most frequent in adults. It usually develops in the skin, and has the characteristics of epithelioma of the skin elsewhere, being of slow growth, and attacking and infecting the glands late, sometimes growing for ten, fifteen, or twenty years, and causing extensive destruction. The mildest form of epithelioma is that known by the name of *rodent ulcer*, or Jacob's ulcer, which tends to heal in some parts while spreading in other directions, and has a tendency to contraction in its base, so that the ulcer does not spread rapidly, and the surrounding skin is drawn in around it, making folds and wrinkles. Even the microscopic appearances are deceptive, but true epithelial "nests" can be found if a proper search be made. Epithelioma of the skin in this region is very apt to develop from a **seborrhœa**, a chronic inflammation of the sebaceous glands, which forms a thickened patch in the superficial part of the skin from a quarter of an inch to an inch in diameter, covered with a dry, scaly secretion resembling dandruff. The first signs of the change to epithelioma are an increased thickening of the skin and a tendency to ulceration, and when these appear the entire patch should be excised. Epithelioma developing in these glands may be multiple, appearing at the same time in different parts of the face.

Treatment.—Epithelioma of the face requires complete extirpation. Although this may be done with caustics or the cautery, the knife is the only satisfactory agent. If the tumor is very small (less than half an inch in diameter), the incision may be made one-quarter of an inch from the nearest evidence of disease, but if it be of considerable size, half an inch of sound skin should be sacrificed on all sides. The gap in the skin can be filled by a plastic operation or by Thiersch's skin-grafts.

Carcinoma of the Lip.—Cancer of the lip is a disease almost exclusively limited to men, particularly to those who lead out-door lives exposed to the weather, and the smoking of a short pipe appears to be a frequent exciting cause. It may also originate in neglected ulcers of the lip following some trifling scratch, or herpes. It is almost invariably an epithelioma. The disease is more unfavorable in the lower lip, for when it occurs in the upper lip it is very often in the form of an ordinary epithelioma of the skin, and extends to the mucous membrane secondarily. Epithelioma of the lip is rare in women, but when it does occur in them it is quite as likely to appear in the upper lip as in the lower.

Clinical Varieties.—The disease appears in several different types. It may begin as a very chronic ulcer, with an indurated base, causing little annoyance. In other cases it first appears as a fissure of the lip, extending quite deeply into the tissues and not spreading much on the surface, and this form usually grows more rapidly. Another variety is a sprouting papillomatous growth, which tends to rise above the level of the lip, but does not, as a rule, attack the tissues below the mucous membrane. A fourth form appears as a thickened patch in the mucous membrane, which has very little tendency to ulceration, and may remain quiescent for a long time. The lymphatic glands are involved rather late in epithelioma of the lip, and in examining for them it is well to insert the finger and press on the floor of the mouth, while the other hand feels beneath the chin, for very small glands

may be found in this way which would otherwise escape detection. Occasionally the small gland which lies on the border of the jaw near the facial artery is affected. Epithelioma of the lip may spread in the skin or in the mucous membrane, but generally both are involved. The great majority of these tumors are situated near one angle of the mouth, and occasionally they lie directly at the angle. Instances have been reported in which epithelioma has appeared on the upper lip at the point of contact with a cancer of the lower lip, apparently being due to infection or grafting of the malignant tumor. The progress of the disease is not rapid, and it may extend slowly for four or five years, until the entire lower lip is destroyed. The glands of the neck are then generally very much enlarged and the patient suffers much pain, but in the earlier stages pain is not a marked symptom. Hemorrhage from these tumors is also rare, and the patient is annoyed simply by the foul discharge.

The **diagnosis** of epithelioma depends upon the slow growth of the tumor, its tendency to ulceration, and the marked hardness of its tissues. The primary lesion of syphilis occasionally leads to error, but the glands are involved early in syphilis, and the chancre has a more inflamed appearance and its surface is glazed, while the ulcer of cancer is sloughing or covered with the peculiar granulations of epithelioma. In doubtful cases a piece should be excised for microscopic examination.

Fig. 665.

Epithelioma of the lower lip, showing lines of excision when the tumor is near the angle.

Treatment.—The results of treatment by operation are good and have been improving, so that of the average hospital cases one may hope to save forty or fifty per cent. by thorough operation, while in cases operated upon early the percentage of cures ought to be considerably above this. The operation consists in free excision of the tumor, cutting at least half an inch away from the diseased tissue. The wound can be brought together best, if the tumor is not too large, by making the incision V-shaped. (Fig. 665.) If it is necessary to remove more than one-half of the lower lip, however, Malgaigne's excellent method of filling the gap is to be used. This consists in making the excision in such a way as to leave a square defect in the lip, then making two horizontal incisions on each side, the lower pair beginning at the bottom of the wound and the upper pair beginning at the angles of the mouth, dividing the entire thickness of the cheek, and forming two rectangular flaps, which are drawn together to cover the gap. Along the upper edge of the flaps which form the new lip the mucous membrane is sutured to the skin. It is possible to remove half or even three-quarters of the lower lip without leaving a permanent deformity, for although the mouth is much drawn up immediately after the

operation, in the course of from three to six months the tissues stretch out and the mouth becomes natural in appearance. The region under the chin should always be explored by a transverse incision, as the glands will occasionally be found enlarged, but so embedded in the fat as not to be recognized through the skin. In long-standing or rapidly growing cases the submaxillary region should be thoroughly dissected and all lymphatic glands removed, even if not evidently diseased. The necessity for this precaution is shown in many instances where secondary deposits may cause the death of the patient even when no local recurrence takes place, as in the case illustrated in Fig. 666.

Fig. 666.

Carcinoma of glands of the neck secondary to epithelioma of the lower lip, which remained free from local recurrence after excision.

Cysts.—**Sebaceous cysts** of the face are very common, especially on the cheek, just below the eye, near the border of the lower jaw, and on the forehead. For dermoid cysts, see page 82. **Mucous cysts** are very common in the lips, forming translucent tumors projecting under the mucous membrane, which is greatly thinned and often adherent over them, so that it is difficult to dissect it up. They should be treated by excision or else by incision and a thorough cauterization of the lining membrane with a drop of pure carbolic acid. If the membrane is not destroyed, the cysts generally form again like cysts elsewhere. **Hypertrophy of the mucous glands of the lip** may make a thick fold of mucous membrane just within the mouth, producing the malformation known as *double lip*. It can be treated by excising the hypertrophied tissues between elliptical incisions and suture of the wound, if the deformity is sufficient to make any treatment necessary. **Cysts of the Meibomian glands** are not uncommon in the eyelids, but are usually small. When inflamed they form a very obstinate variety of "sty," which requires free incision and extirpation of the sac to obtain a permanent cure.

INJURIES AND SURGICAL DISEASES OF THE NOSE.

Injuries.—Fractures of the nose are considered in the chapter on Fractures. A severe blow upon the nose, even without fracture, may form a hæmatoma of the septum which may block up the interior of the nose, and if not promptly absorbed may become infected and result in abscess or in necrosis of the bone or cartilage. In cases of injury of the organ, there-

fore, the septum should always be inspected, and if a hæmatoma be found it should be evacuated promptly by incision.

Deformities.—The rare congenital deformities of the nose have already been considered. The acquired deformities may involve either the bones or the soft parts. The nostrils may be occluded as a result of cicatricial contraction from ulcers due to tuberculosis or syphilis. The whole organ may be driven to one side by a severe blow and fixed in this position, or the bridge may be depressed or the septum deflected as the result of fracture. Curvature of the septum may be caused by irregular development. Necrosis is usually of syphilitic origin, and may result in the loss of all the bony framework, and the soft parts may also be destroyed. The removal of tumors may compel the partial or complete destruction of the organ.

Treatment.—Many of the deformities of the nose are capable of correction by operation, and when the soft parts are intact it is essential, if possible, that this be done without an external wound. It is feasible to divide the bones by means of small saws or fine chisels inserted through an internal or a very small external wound, and, having divided them, to keep them in place by the apparatus described under fractures of the nasal bones until they become ossified in their proper position.

Deflected Septum.—A badly deformed septum can be forcibly corrected by strong forceps and held in place by a long, stout pin. The latter is driven into the frontal bone or vomer, so that it lies on one side of the septum. Or the cartilage can be cut away on the side towards which it projects and be removed. In the latter operation a small incision is made in the mucous membrane, the mucous membrane and the perichondrium are separated from the cartilage, and the latter is divided with a strong knife. A small elevator is passed through this opening and the perichondrium stripped up on the other side, when the cartilage can again be divided at the upper part of the incision and removed. The wound is limited to one side of the septum, in order to avoid the formation of a permanent opening between the two nostrils. It was at one time suggested that by making a permanent opening in the septum the air would pass through both nostrils and the functional effect of the deformity would be removed; but experience has shown that the edges of the opening are liable to ulcerate, and that crusts collect about it and produce a constant irritation which annoys the patient more than the deformity of the septum. Before operating upon the bones, particularly in operations without external incisions, the greatest care must be taken to make the interior of the nose healthy and free from septic material, because the bones lie in such intimate connection with the base of the brain that any infection producing an inflammation of the veins might easily extend backward within the skull and result in a fatal meningitis or abscess.

Restoration of the Nose.—When the bones of the nose have been lost by disease or accident they can be restored by various plastic operations, or their place can be taken by apparatus fitted to support the soft parts. In some cases satisfactory results have been obtained by inserting celluloid or metal supports, shaped like a spindle, between the skin and the mucous membrane, so as to restore the external outline of the organ. Often the soft

parts are also defective and must be replaced. Of these plastic operations the best known are as follows:

A flap can be cut from the forehead with its pedicle at the root of the nose, and turned down so as to supply the soft parts. If the lining of the nose is absent, the flap is turned over with its raw surface external, the latter being grafted with skin later. If the mucous membrane is intact, the flap can be simply drawn down so that the skin surface is outward and the raw surface is in contact with the bone and mucous membrane. The flaps can also be cut from the side of the nose or the cheek, but they can be taken from the forehead with the least amount of disfigurement, especially if the wound is grafted with skin.

If the entire nose is absent, the most practical method of obtaining a bony framework is that suggested by König. A flap of the usual shape for covering the nose is outlined on the forehead, the incision being carried through the periosteum, and then with a sharp chisel the external surface of the bone is shaved off in a thin layer, but left attached to the periosteum on the under side of the flap. The flap is then turned down, and if the mucous membrane is intact, the bone surface is placed next to the mucous membrane; but if there is no mucous membrane, the flap should be turned over, with the bony surface directed outward, the latter being covered at once with flaps of skin taken from the cheeks, or left to granulate and covered later by skin-grafts. The old method of supplying the nose with a piece from the arm by the operation of Tagliacozzi is now usually varied by using a finger, thoroughly removing the nail and matrix from it. The soft parts on the palmar surface of the finger are incised in the middle line and turned aside, forming two lateral flaps. The edges of the nasal opening are freshened, and the edges of the flaps on the sides of the finger are sutured to the edges of the aperture. The finger and hand are then securely fixed in front of the face with plaster of Paris bandage strengthened by wire. After two weeks have elapsed, one digital artery is tied, and a week later the other is ligated, and finally the finger is severed from the hand. Subsequent small operations are necessary to improve the shape of the nose. The bones of the transplanted finger are very apt to atrophy, so that the result is not so good as might be expected, and the necessity for keeping the hand in this one position during several weeks is a serious drawback, while a minor trouble is the difficulty of thoroughly destroying the matrix of the nail.

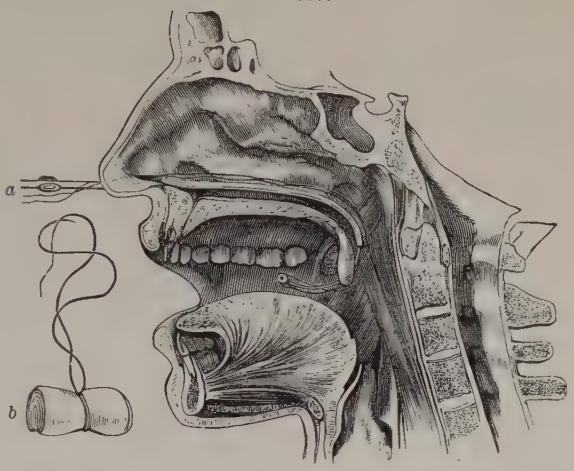
Metal Supports.—The difficulty of forming a suitable bony skeleton for the nose has induced surgeons to try metallic or other substitutes, the most practical of these being a platinum tripod, one leg of the tripod supporting the bridge of the nose and the other two supporting the alæ. The tripod is carefully made to fit the individual case, and it should not be too large, for the soft parts are generally scanty and are likely to shrink. When the soft parts are fairly complete, the nasal opening may be exposed to insert the support by **Rouge's operation**. This consists in seizing the upper lip with sharp retractors and drawing it upward over the tip of the nose, making an incision in the mucous membrane of the lip near its connection with the gum, and completely detaching the upper lip from the bone.

With the periosteal elevator the periosteum and all the soft parts above it are separated from the anterior surface of the upper jaw on both sides. In this way all the soft parts of the nose and cheek are dissected up, so that the fingers can be passed upward from the mouth under the skin of the face as high as the root of the nose. The platinum support is then pushed up under the flap, and its upper leg fitted into a small hole which is bored in the stumps of the nasal bones or in the frontal bone. The two lower legs are fitted into holes bored in the superior maxillæ at the lower border of the nasal opening. The soft parts are then allowed to fall into place, the skin of the nose being held up in the natural position by the metal support. The soft parts are lightly bandaged down upon the support and the facial bones, a few sutures being inserted in the wound in the mucous membrane of the upper lip. The metal support is exposed in the nose, not lying between the skin and mucous membrane, but lifting up both the skin and mucous membrane with its frame. In spite of the apparent great extent of the wound, the disturbance after the operation is slight. This artificial support has been worn for years without irritation, but occasionally its pressure develops ulcers and compels its removal. It will be remarked that the majority of these plastic operations require the production of new scars upon the face. While these are made inconspicuous by the modern methods of treatment, skin-grafting, etc., they are so serious a drawback that, if the patient is well-to-do, it is always a question whether he would not be better served by an artificial nose made of some light material (aluminium) covered with wax and painted. This is held in place by spectacles, and the cosmetic effect is often better than that of the best plastic surgery.

Epistaxis.—Hemorrhage from the nose may originate from an injury, an acute inflammation, or an ulcer, and in women it is occasionally seen accompanying menstruation or serving as a substitute for that function. The hemorrhage often comes from a small artery on the lower part of the septum, which is liable to injury by ulceration or by the finger-nail, and it can often be arrested by a small clamp. If the epistaxis does not originate from this small vessel and its source cannot be found, it can sometimes be controlled by snuffing up into the nose some styptic solution, such as a mixture of alum and tannin, or simply very hot or very cold water. A spray of cocaine or antipyrin will contract the vessels and control capillary oozing from the mucous membrane of the nose. If it does not yield to this treatment, the nose must be plugged ; and it will not answer simply to pack the cavity from the front : the posterior nares must also be occluded. A very ingenious instrument is Bellocq's canula (Fig. 667), which is introduced through the nostril, and contains a curved steel spring, which on being pushed through the canula shoots forward under the soft palate into the mouth, carrying a string, which is drawn out and fastened to the tampon. The instrument is then withdrawn and the tampon pulled into the posterior naris. A small soft catheter can also be used for this purpose, being passed backward through the nostril until it hangs down into the pharynx, where it is picked up with forceps and drawn forward, the string being secured to this and pulled backward through the mouth and the posterior naris and forward to the nostril. It is an easy matter to attach a pad

of cotton to the end of the string in the mouth, and under the guidance of the finger push it backward through the mouth and draw it up into the posterior naris. This plug of cotton should be so large that it will not completely enter the posterior naris, but will simply remain wedged in place. The nose is then packed from the front, and the string attached to the posterior pad is secured to another pad, which rests against the anterior nostril and holds the packing in place. It is then impossible for any hemorrhage to take place; but the packing must not be left too long, lest the blood decompose and septic infection result.

Fig. 667.



Section of head showing Bellocq's canula (*a*) in place; *b*, plug with string, ready to attach to the canula.

Foreign Bodies.—*Foreign bodies* are not infrequently found in the nose, being introduced by accident or by intention. They can be discovered by a probe or by inspection, and can be removed easily. Sometimes it is easier to push them back into the pharynx and to remove them thence, but if this is attempted in a child he should be held with his head hanging down, so that the foreign body shall not enter the larynx when dislodged. A very good instrument for the removal of foreign bodies is the scoop invented by Gross, but a loop of wire or an ordinary hair-pin makes a very efficient substitute. Foreign bodies remaining in the nose for some time become encrusted with calcareous matter, and thus form masses of considerable size, known as *rhinoliths*. Insects sometimes become lodged in the nose, and flies may lay their eggs and the larvæ hatch out there. The latter are particularly difficult to dislodge, and a long course of cleansing may be necessary to rid the nose of them.

Hypertrophy of the Turbinated Bones.—Hypertrophy of the turbinated bones is not uncommon, and may require cauterization by pure carbolic acid or partial removal by surgical means, an operation, however, which we believe to have been done too frequently and to be destined to a less prominent place in the future. The parts are anæsthetized with cocaine and the bone removed by small saws.

Necrosis. Ozæna.—Necrosis of the bones of the nose is not uncommon as the result of inflammation, and the sequestra require removal. This can generally be done from within under cocaine anæsthesia. Necrosis is usually marked by a foul discharge, but a foul discharge from the nose does not always indicate ulceration and necrosis, for it is found in ordinary ozæna, a condition which is accompanied by hypertrophy or atrophy of the mucous membrane, the latter being generally a second stage of the first. The foul-

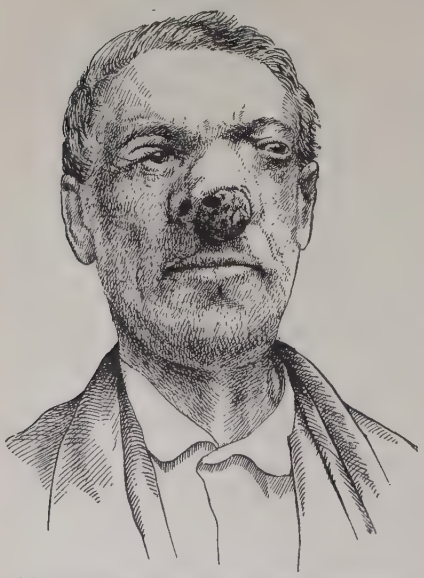
ness of the discharge in ozæna is caused by the crusts formed by the disordered secretion and the retention of the discharges.

The mucous membrane of the nose is liable to a great variety of inflammations, of which we need only mention **diphtheria, syphilis,** and **tuberculosis.** Tuberculosis is generally a superficial affection of the mucous membrane only, whereas syphilis is very prone to attack the bones as well as the membrane. The consideration of the superficial diseases, however, belongs more properly to the specialist.

Tumors.—Tumors of the nose occur both within that organ and outside of it. Outside are found **fibroma, angioma,** and **epithelioma,** as in other parts of the face. **Dermoids** are very rarely found at the root of the nose. The most common internal tumors are **polypi.** The mucous polypi have the structure of the mucous membrane, and resemble hypertrophy of that tissue. Sometimes the glands of this hypertrophied mucous membrane become obstructed and cystic changes occur. In other cases the polypi are made up of *myxomatous*, *fibrous*, or *angiomatous* tissues. Ordinary mucous polypi originate apparently from chronic catarrh, and are most frequently situated in the upper anterior part of the nasal cavity, especially at the end of the middle turbinated bone. The polypi cause obstruction to breathing, and nasal discharges of mucus, blood, or pus, and they may affect the hearing by obstructing the Eustachian tube.

Treatment.—Polypi are removed by grasping the pedicles with forceps and twisting them out, by scraping them off with a sharp spoon or curette, or by snaring them with a cold wire or a galvano-caustic loop. The removal of larger ones may occasion some hemorrhage, but it can be controlled by ice-water or by some styptic application, such as alum and tannin.

FIG. 668.



Fibrous polypus of the nose. (After Ashhurst.)

Naso-Pharyngeal Polypus.—Another form of polypus connected with the nose, although not strictly a nasal tumor, is the so-called naso-pharyngeal polypus, a fibrous tumor which grows most frequently from the basilar process at the base of the skull. (Fig. 668.) Growing forward from this point, it sends out projections into the pharynx, the nose, the sphenoidal or frontal sinuses, and the antrum of Highmore. These polypi also spring from the margin of the foramen lacerum anterius, or the wall of the pterygo-maxillary fossa, and then extend between the muscles in all directions, appearing on the cheek above and below the zygoma, and penetrating the orbit or the antrum. This polypus tends to form new attachments in every direction, and is sometimes

disconnected from its original base. It is found only in the young, and almost invariably in males, being quite common just about puberty. Many of these tumors undoubtedly undergo spontaneous atrophy. In structure they are either soft or hard fibromata, often very vascular, but they are liable to return when removed, and they are also very liable to degenerate into true sarcoma. These growths appear to be rather rare in America. Their symptoms are those of nasal obstruction, distention of the nose, orbit, and pterygo-maxillary space, and the ordinary deformity of tumors of the upper jaw, combined with severe hemorrhages from the tumor, which may prove fatal. They may cause obstinate neuralgia by pressure.

Treatment.—Operations upon naso-pharyngeal polypi are useless unless the base of the tumor is reached and destroyed, and the operation is often very formidable. In order to reach the base some surgeons have divided the bones of the nose on one side, and then broken the bones opposite and turned the whole organ over as a flap. Others have detached the soft palate and cut through the hard palate for the same purpose. Still others have removed the upper jaw, that bone being sacrificed or being left attached to the soft parts and replaced after the operation. If the diagnosis can be made before the polypus has grown large, the tumor may be removed through the natural passages by the cold wire or galvano-cautery loop, or by passing a sharp spoon through the nose to the base of the polypus, guiding it by the finger passed through the mouth into the pharynx, and scraping the tumor away from its attachment to the bone. The hemorrhage during this manœuvre may be severe, and it is necessary to operate with the patient's head hanging down over the end of the table, lest he be suffocated by the blood, but it is easily controlled by pressure after the tumor is removed. Before the tumor is detached the mass should be secured by a volsellum or a thread passed through it, lest it fall into the larynx.

Rhinoscleroma.—Rhinoscleroma is a disease of the soft parts of the nose, pharynx, and mouth. It appears in the shape of hard flat nodules of small size forming in the skin and mucous membrane, and usually beginning far back in the lower part of the nose, and progressing forward to the nostrils. The sense of smell is not disturbed, and the only sign of the disease may be an obstinate catarrh with an occasionally purulent discharge. These nodules spread over the entire pharynx, and sometimes over a part of the tongue and mouth, down into the larynx. They appear to be caused by a special bacillus, which has been isolated. In the later stages the nodules form connective tissue and the mucous membrane contracts, and this contraction may cause such obstruction of the larynx as to compel tracheotomy. No cure is known for this disease, but fortunately it is rare in this country.

Diseases of the Nasal Sinuses.—Frontal Sinus.—The frontal sinus in the adult occupies the internal two-thirds of the orbital ridge and extends upward about one-half inch above the orbital margin. In children it is very small—scarcely larger than a pea.

Fracture.—A fracture of the superior wall involves the base of the skull, and any fracture of the sinus involves great liability to sepsis, because the secretions and blood may be retained in the sinus and may decompose. Even if the fissure does not extend through the base of the skull, intra-

cranial infection occurs readily, and great attention must be paid to drainage. If a wound exists, the sinus should be drained through it, and if there is no wound, a trephine opening must be made into the sinus upon the first indication of any infection extending towards the brain.

Distention of the Sinus.—The opening into the frontal sinus (the infundibulum) can be reached, but with difficulty, through the nose with a probe, and should be sought at the anterior end of the middle turbinated bone. The retention of secretion in the sinus by obstruction of the infundibulum by a polypus or by inflammatory swelling causes severe frontal headache, often limited to one side, with tenderness over the sinus, and occasionally an intermittent discharge of mucus or pus, particularly when the patient raises his head after being long in a recumbent position. If the retention is complete, and particularly if pus forms in the sinus, causing *an empyema*, the sinus is distended, its wall naturally giving way where it is the thinnest, towards the orbit and the nose. This may result in diplopia, owing to the displacement of the eyeball, and choked disk may follow. There may be an intermittent discharge of mucus, or possibly lachrymation, and if the infection is severe there may be fever and chills, and meningitis may follow. The method of lighting up parts of the face by means of the electric light in a dark room may be employed in the diagnosis, the lamp being enclosed in an opaque capsule with one open side which is applied to the forehead, just above the sinus, so that the light shines through the bone. The normal sinus appears as a bright spot, but one containing pus remains dark. The treatment of empyema consists in drainage, and to establish this successfully through the nose by way of the infundibulum is seldom possible. As a rule, it is best to make a small incision in the eyebrow after shaving it, expose the bone, and make a small trephine-opening, or cut away the anterior wall of the sinus with a chisel. After the sinus has been opened a small drainage-tube may be passed through the infundibulum into the nose. Frequent irrigation is necessary afterwards. The operation should be done as early as possible, in order to avoid necrosis.

Foreign bodies are sometimes deposited in the sinus, such as pistol-balls, or fragments of weapons or missiles, and they should be sought for and removed when the sinus is wounded. Insects have also been known to find their way up into the sinus through the nose, and their removal is exceedingly difficult. The patient should inhale chloroform, in the hope that the vapor may kill the insect; but an empyema is apt to follow from the infection caused by the dead insect.

Tumors occur in the frontal sinus, bony, myxomatous, and fibrous, and also malignant. The most common is *osteoma*, which arises especially from the cribriform plate and grows to a considerable size, sometimes perforating the orbit. The osteomata are liable to necrosis, the small pedicle breaking off and interrupting the blood-supply. The result of the necrosis is a septic condition and sometimes meningitis, which explains the very high mortality in operations for these necrotic tumors. *Malignant tumors* of the sinus usually begin with the symptoms of an empyema, and it is impossible to make the diagnosis until they show themselves externally, although the pain which they occasion is especially severe and continuous.

Ethmoidal Sinuses.—The ethmoidal sinuses, on account of their small size and more retired position, seem to be less liable to disease than the frontal. Myxomatous *polypi* grow in them, and *empyema* occurs, but *necrosis* of the bone is rare. When there is inflammation of these sinuses it is necessary to drain the cells, either by the nose, the turbinated bone being removed to give access to them, or by the orbit. The latter is the better method, for although any injury to the superior oblique muscle would result in strabismus, the pulley of the muscle is usually displaced by the swelling of the os planum, so that there is little danger of its being injured by perforation of the bone at that point. The signs of disease of these cells are headache, nasal obstruction, and occasionally exophthalmos, diplopia, or "choked disk." Disease of the ethmoid may be suspected if these symptoms are found combined with a disturbance of the orbit on both sides, disease of the frontal sinuses usually being unilateral.

Sphenoidal Sinuses.—The diagnosis of diseases of the sphenoidal sinuses is practically impossible, for the symptoms are the same as those of the ethmoidal. The sphenoidal sinuses can be reached by means of a probe curved at the end and inserted in the nose to a depth of six and one-half centimetres from the nostril, the probe being made to follow the septum and then rotated for a quarter of a circle, when its extremity should enter the passage into the sinus. Its passage will relieve any retention.

CHAPTER XXVI.

SURGERY OF THE TONGUE, CHEEKS, GUMS, JAWS, AND SOFT AND HARD PALATE.

Injuries of the Gums, Cheeks, Jaws, and Soft and Hard Palate.—These may result from bodies either thrust through the cheeks or entering through the mouth. *Burns* and *scalds* of these parts may result from hot substances or hot fluids, or steam, or caustics, such as ammonia or strong acids. The injury from burns or scalds is not usually severe, as the hot substance is quickly ejected; but those received from caustic alkalies or acids are apt to be followed by sloughing of the mucous membrane, and are often marked by contraction and deformity. Incised and lacerated wounds of the cheek, if they involve the duct of the parotid gland, may be followed by a salivary fistula. Incised and lacerated wounds of the gums, cheeks, and palate generally result from falls upon sharp or blunt bodies, such as sticks, pencils, or pipe-stems, which enter the mouth, and are forcibly driven into the tissues; they may also result from gunshot wounds, Perforation of the soft and of the hard palate may occur as the result of these injuries. Hemorrhage following wounds of these parts is usually very profuse at first, but, if no important vessel has been divided, soon ceases.

Treatment.—If a bleeding vessel is exposed in the wound, it should be secured by a ligature, and the wound carefully explored to discover if a foreign body is present in it. This, if found, should be removed, and, after irrigation with sterilized water or boric acid solution, the edges of the wound should be approximated with sutures passed through the mucous membrane and subjacent tissues. If the wound involves the skin, the external wound should be closed by a separate row of sutures. The patient should be given only liquid nourishment, and instructed to wash the mouth constantly with some weak antiseptic solution. If caustic alkalies or acids have been taken into the mouth, their action should be arrested by the use of acid or alkaline solutions, as the case may be: the subsequent treatment of the wound, as in the case of burns and scalds, consists in keeping the parts clean by the employment of mild antiseptic mouth-washes, and the prevention of adhesions and contraction by a packing of iodoform gauze.

INJURIES OF THE TONGUE.

These may consist of burns, scalds, injuries from caustic alkalies or acids, stings of insects or serpents, incised and lacerated wounds.

Burns and Scalds of the Tongue.—These injuries generally result from the application of hot solids or liquids, and are usually superficial, being accompanied by burning and pain for only a few hours; whereas the injuries following the application of caustic alkalies or acids are deeper and

accompanied by great pain and swelling, and are more likely to be followed by sloughing. If the latter complication occurs, the tongue may be bound down by adhesions and its motions seriously interfered with.

Bites of *animals* and *stings* of *insects* or *serpents* are followed by great swelling of the organ, which has in a few cases caused a fatal termination.

Incised and Lacerated Wounds of the Tongue.—These are caused by sharp or blunt instruments, or by the teeth when the tongue is protruded. The principal dangers in wounds of the tongue are from hemorrhage, and later from septic infection. Foreign bodies may be lodged in the tongue, and, the wound becoming infected, dangerous secondary hemorrhage results.

Treatment.—In superficial burns or scalds of the tongue, or injuries from caustics, the use of a boric acid solution, or of a solution of carbolic acid, gr. i; carbonate of sodium, gr. xv; water, f℥i, will relieve the pain and act as a mild antiseptic. In cases of stings of insects or bites of animals or serpents, the swelling of the tongue may be so great that respiration will be interfered with, in which case free incisions should be made into the organ, being generally followed by rapid decrease in the swelling. In incised and lacerated wounds of the tongue the wound should be carefully explored, any foreign body should be removed, and the bleeding arrested by the application of ligatures to the bleeding vessel, if possible; but if it cannot be exposed in the wound, the clots should be removed, and the edges of the wound brought together by deep sutures of silk or catgut, which serve at the same time to control the bleeding and to coaptate the surfaces of the wound. Antiseptic mouth-washes should be freely used until the wound is healed. Repair is usually prompt, and the sutures may be removed at the end of a week.

DISEASES OF THE MOUTH AND TONGUE.

STOMATITIS.

Inflammation of the mucous membrane of the mouth presents itself in a number of different forms, but those which most concern the surgeon are ulcerative, syphilitic, and gangrenous stomatitis.

Ulcerative Stomatitis.—This condition of the mucous membrane results from wounds, scalds and burns, caustics and acids, the irritation of rough or carious teeth, and the use of tobacco; the ulceration following the use of mercury may also be included under this head. **Symptoms.**—The ulceration usually begins in the gums of the lower jaw, near the margin of the teeth, and subsequently spreads to the floor of the mouth, the tongue, the lips, and the cheeks. The gums are swollen and congested, and the surfaces of the ulcers are covered with grayish sloughs. The ulcers bleed upon the slightest touch, the teeth become loose, and necrosis of the alveolar margin of the jaw is apt to occur. Profuse salivation is present, the breath is foul, and the submaxillary glands are often tender and swollen. **Treatment.**—This consists in frequent and thorough cleansing of the cavity of the mouth with mild antiseptic solutions—boric acid, ʒi to water f℥vi, or a solution of carbolic acid, gr. xii; chlorate of potassium, ʒi; water, f℥vi, and the ulcerated surfaces should be touched with a solution of nitrate of silver, gr. x to water f℥i. The patient should be placed upon a liquid diet, smoking

should be prohibited, and quinine and tincture of chloride of iron should be administered.

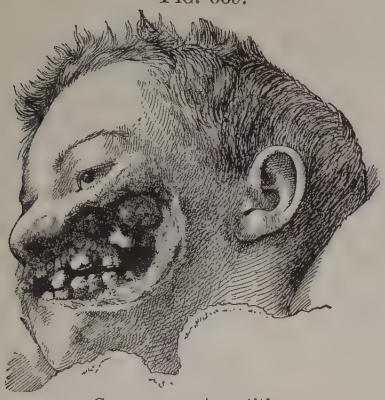
Syphilitic Stomatitis.—This affection of the mucous membrane of the mouth and fauces frequently accompanies the development of the cutaneous eruption in secondary syphilis, and is characterized by the occurrence of a general inflammation of the mucous membrane of the mouth and fauces, with the development, at points, of whitish patches or mucous plaques, due to the thickening and degeneration of the epithelium. The diagnosis of this affection from other forms of stomatitis can be made by the appearance of the parts and the coincident development of the cutaneous lesions of syphilis. **Treatment.**—In syphilitic stomatitis the local treatment consists in the use of a mouth-wash of carbolic acid and chlorate of potassium, and the application of a ten-grain solution of nitrate of silver to the mucous patches; the patient should not be permitted to use tobacco, as it increases the irritation. The constitutional treatment is most important, and consists in the use of iodide of mercury in doses of one-quarter to one-half grain, and occasionally, if the lesions do not disappear promptly, the addition of five- or ten-grain doses of iodide of potassium may be followed by good results.

Gangrenous Stomatitis.—Noma.—This affection, which is also described as *cancrum oris*, is sometimes observed in children after the eruptive fevers, and is most frequently seen following measles. The subjects in whom it develops are usually poorly fed, or the inmates of children's homes, where the food and hygienic surroundings are very poor. The special organism producing this affection has not been definitely isolated, but it probably results from infection with the bacillus of malignant œdema, or from a mixed infection caused by this bacillus and the specific bacillus of the disease which it follows; capillary thrombosis results, and is followed by rapidly spreading gangrene. The gangrenous process once established spreads to the soft parts, and soon extends to the bones of the jaws, producing rapid and extensive necrosis, accompanied by marked constitutional disturbance, high fever, rapid pulse, and often free diarrhœa. The disease is sometimes fatal in a few days; if, however, the patient survives, separation of the gangrenous tissue occurs, and repair is followed by great contraction and deformity of the face.

Symptoms.—In a patient in whom this affection is developing the offensive odor of the breath often first attracts attention, and upon examination of the mouth a spot of ulceration is usually seen upon the mucous membrane of the cheek, or upon the gums of the upper or the lower jaw. The patient shows a marked rise in temperature, and the pulse becomes rapid and feeble. In a few hours a dusky red indurated spot appears upon the cheek, lip, or chin over the seat of the ulceration in the mucous membrane, and if the mouth is now inspected, dark sloughs are found to occupy the seat of the former ulceration. The gangrenous process spreads rapidly and involves the tissues of the cheeks, and a black gangrenous patch soon takes the place of the dusky red indurated spot; the process soon involves the gums and jaws, the teeth become loose and fall out, and the alveolar process and body of the jaw become necrosed. (Fig. 669.) Profuse offensive discharge accompanies this affection, and the patient usually dies after four or five days. Recovery, however, may occur in cases where

extensive destruction of the cheek or necrosis of the bone has taken place. We have recently had under our care a case in which almost the entire lower jaw and a portion of the upper jaw were necrosed and were removed, in which recovery finally took place. (Fig. 670.) After the sepa-

Fig. 669.



Gangrenous stomatitis.

Fig. 670.

Necrosis of the lower jaw following gangrenous stomatitis.

ration of the sloughs and dead bone, great contraction and deformity often result; if the lips are involved, the oral aperture may be much contracted, or the lower jaw may be so firmly bound down by adhesions that the mouth cannot be opened, or the tongue may be firmly adherent to the floor of the mouth. Coincidently with the development of gangrenous stomatitis in female children *noma pudendi* is sometimes observed.

Treatment.—As soon as it is evident that the gangrenous process has attacked the gums or the cheeks, the patient should be anæsthetized, a mouth-gag inserted to expose the oral cavity widely, the sloughing tissues removed with forceps and scissors or with a curette, and the surface thus exposed cauterized with nitric acid or the actual cautery. A mouth-wash of chlorate of potassium and myrrh, or a weak permanganate of potassium solution, should be used freely afterwards. The cauterization should be repeated in a few days if the disease continues to spread or if new areas of gangrene develop. The patient should be given stimulants freely, with quinine and iron, and allowed a most nutritious diet. Under this method of treatment we have seen the disease arrested, with moderate destruction of the tissues, and have also observed arrest of the process, followed by recovery in well-advanced cases.

TUMORS OF THE MOUTH.

Epithelioma of the floor of the mouth is a comparatively rare affection as a primary growth, but may result from extension from the tongue or the gums. The **treatment** consists in removal of the growth through the mouth or through an incision made below the chin.

Nævus of the floor of the mouth is also a rare affection, and its treatment is similar to that employed in nævus in other localities.

Ranula.—This consists of a thin-walled cystic swelling springing from the floor of the mouth beneath the tongue, and containing a thick, clear

fluid. It may be unilateral or bilateral. This cyst was formerly supposed to be due to obstruction of the duct of Wharton, and in a few cases this may be the cause; but the majority of ranulæ are simply retention-cysts formed in the mucous glands in the floor of the mouth. A ranula may vary in size from that of a cherry to that of a small egg, is usually unaccompanied by pain, and attracts the patient's attention only by its interfering with the movements of the tongue in speech and in swallowing. When these cysts attain a large size some fulness may be noticed in the submental space.

Treatment.—The most satisfactory treatment consists in grasping the wall of the cyst with toothed forceps and with curved scissors cutting away a portion of the cyst-wall. If the openings of Wharton's duct are seen, they should not be included in the portion of the cyst-wall which is excised. After emptying the fluid from the cyst, its walls should be cauterized with a solid stick of nitrate of silver or with a thirty-grain solution of chloride of zinc. A strip of iodoform gauze should be loosely packed into the cavity of the cyst and allowed to remain for a few days. A seton may also be employed, but its use is not so likely to be followed by obliteration of the cyst as is the operation just mentioned.

Acute Ranula.—This consists in a sudden swelling of the submaxillary gland, which becomes tense and painful, and arises from obstruction of the duct of the gland by a plug of mucus. The pain and swelling develop suddenly, and are much aggravated during the mastication of food. **Treatment.**—If the openings of the ducts of the submaxillary gland are examined, the end of a mass of inspissated mucus may be found in the orifice of the duct, or a mass may be felt below the mucous membrane in the course of the duct. This should be removed by forceps, or the duct should be slit open with a sharp narrow knife and the obstructing material removed. Rapid disappearance of the pain and swelling occurs as soon as the saliva is allowed to escape.

Dermoid Cysts of the Floor of the Mouth.—These are sometimes described as congenital sebaceous cysts, or thyroid dermoids, of the floor of the mouth, and are cysts containing sebaceous matter, hairs, and cholesterin, being true dermoids. They rarely take on rapid growth and produce marked deformity or discomfort before the age of puberty. They do not possess the translucency of an ordinary ranula, are more deeply seated, are covered by the mucous membrane and muscles, are most frequently situated in the median line, and are often attached to the hyoid bone. The cyst may present an elastic fluctuating swelling projecting into the mouth, and may also cause marked swelling beneath the chin. (Fig. 671.) These growths are rarely painful, but cause difficulty in speech and swallowing by pushing the tongue upward and interfering with its motions. They often attain the size of a hen's egg or of a small orange.

Fig. 671.

Dermoid cyst of floor of the mouth projecting beneath the chin.

Treatment.—Complete extirpation of the cyst is the only satisfactory method of treatment. This can be accomplished through the mouth, or by making an incision through the skin below the chin. The latter operation is to be preferred, as it is then possible to keep the wound aseptic, but removal through the mouth is a satisfactory operation. In the latter method the mouth should be held widely open with a gag, and the tongue held upward with a retractor; an incision is then made through the mucous membrane over the cyst, the muscles are separated with a director, and the cyst is exposed; this is seized with toothed forceps, and as it is drawn out its walls are separated from the surrounding tissues with the finger or a blunt director, the use of the knife or the scissors rarely being required. When the cyst has been removed, a strip of iodoform gauze is passed to the depth of the wound; this is allowed to remain in place for a few days, and an antiseptic mouth-wash is used frequently until the wound is healed. If external incision below the chin is resorted to to expose the cyst, it is removed by a careful dissection, the wound is drained by a strip of iodoform gauze, the external wound is closed by sutures, and a gauze dressing is applied.

Salivary Calculus.—This consists of a concretion of phosphate and carbonate of calcium, which may form in the salivary glands or in their ducts, and is most frequently met with in the submaxillary gland. If it forms in the substance of the gland it rarely produces marked symptoms unless it attains a considerable size. A small calculus obstructing the duct may produce pain and swelling of the gland. These concretions vary in size from that of a grain of wheat to that of a walnut. **Symptoms.**—If the calculus is impacted in the duct the escape of saliva is arrested, the gland becomes swollen, tender, painful, and hard, and the symptoms are aggravated during the act of mastication. These symptoms should lead the surgeon to explore the gland and duct: by palpating with the finger in the mouth the location of the calculus can usually be ascertained without difficulty. If the obstruction of the duct persists, suppuration is apt to occur, and a fistulous opening may form upon the cutaneous surface. **Treatment.**—When the calculus is situated near the opening of the duct it may be pressed out of the opening with the finger, or after injecting a few drops of cocaine the orifice of the duct may be incised to facilitate its removal; it may then be pressed out of the wound or removed with forceps. The wound usually heals promptly.

DISEASES OF THE TONGUE.

Tongue-Tie.—This is a comparatively rare affection, and consists in an abnormal shortness of the frenum linguæ or of its attachment too far forward towards the tip of the tongue, which prevents the protrusion of the organ beyond the line of the upper incisor teeth. We have seen very few cases of marked tongue-tie in the service of a large children's hospital. If this condition is present the child may experience difficulty in taking the breast, and later impairment of speech may be marked. Any child who is not precocious in talking is apt to be credited with this affection and to be brought to the surgeon for treatment. A very aggravated form of tongue-tie sometimes results from the tongue being bound down by cicatricial adhesions after ulceration of the organ and of the floor of the mouth.

Treatment.—This condition may be relieved by opening the mouth, placing a retractor or the flat end of a director under the free portion of the tongue, and lifting the organ towards the roof of the mouth, thus rendering the frenum tense. The frenum should then be divided for a short distance with scissors, care being taken to cut away from the tongue so as to avoid the ranine vessels. After the frenum has been incised it can easily be torn back for a short distance with the finger. In cases of cicatricial adhesion of the tongue to the floor of the mouth, a plastic operation is required to correct the deformity and secure mobility of the organ.

Elongation of the Frenum.—Cases are occasionally observed in which, from elongation or relaxation of the frenum linguæ, the tongue falls backward when the patient assumes the recumbent posture, and occludes the upper orifice of the larynx, constituting the affection known as *tongue swallowing*. Death has resulted from this condition. It has been observed after a too free division of the frenum, and after operations upon the floor of the mouth, or excision of the central portion of the lower jaw, which interferes with the attachment of the muscles of the tongue. **Treatment.**—This condition should be remedied by excising a portion of the frenum and suturing the edges together, or, if the tongue tends to fall back after operation upon the mouth or the jaw, its tip should be transfixed with a ligature, and it should be drawn forward and secured until adhesions form.

Macroglossia.—Hypertrophy of the tongue, or macroglossia, is a condition which is characterized by a great increase in size of the tongue, the organ being so much enlarged that it cannot be contained within the oral cavity and a considerable portion protrudes from the mouth. The affection is usually congenital, but does not ordinarily attract attention until the end of the first or the second year; we have, however, seen a marked case of this affection in an infant of five months. The disease, which is closely allied to elephantiasis, may be classified as a lymphangioma cavernosum, and presents marked increase and dilatation of the lymphatic vessels, with increase of the blood-vessels and hyperplasia of the connective tissue. The anterior portion of the tongue is usually affected, the base of the organ remaining normal in size. In marked cases a large mass of the tongue is prolapsed, and cannot be retracted within the mouth; the shape of the dental arch may be changed by the pressure and weight of the organ, and the latter may be furrowed

Fig. 672.

Macroglossia.

where it rests upon the teeth ; the portion of the organ which is permanently prolapsed becomes dry and brown. (Fig. 672.)

Treatment.—As long as the hypertrophy of the organ is moderate it causes little inconvenience, but when it fills the cavity of the mouth, or is prolapsed, it gives the patient discomfort and interferes very seriously with taking food. The patient having been anæsthetized and a gag introduced between the jaws, the tongue should be grasped with forceps and drawn forward, a strong ligature being introduced through each side of the tongue to enable the operator to draw it forward and have control of the stump after the removal of the anterior portion of the organ. A V-shaped piece of the tongue, with its apex directed backward, should then be excised, and the edges of the wound brought together by sutures passed through the thickness of the flaps. Hemorrhage is not usually free, but bleeding vessels should be grasped with hæmostatic forceps and ligated ; the deep sutures generally control the bleeding perfectly. If the tissue removed has been sufficient, after the flaps have been sutured the stump is retained in the mouth, and, as a rule, it continues to shrink for some time after the operation. The sutures should be removed in about ten days.

Acute Glossitis.—This condition, which consists in a parenchymatous inflammation of the tongue, is a comparatively rare affection, and occurs more frequently in adults than in children. It may involve one-half of the tongue, constituting *hemiglossitis*, or may involve the whole organ. It may result from bites of insects, cuts, burns, exposure to cold, or septic conditions of the mouth.

Symptoms.—The tongue rapidly increases in size, and may fill the cavity of the mouth so largely that breathing is interfered with ; the organ becomes red and covered with a muco-purulent discharge ; salivation is profuse, and speech and swallowing become difficult and painful. There is at the same time marked constitutional disturbance, as shown by the elevation of the temperature and the rapidity of the pulse.

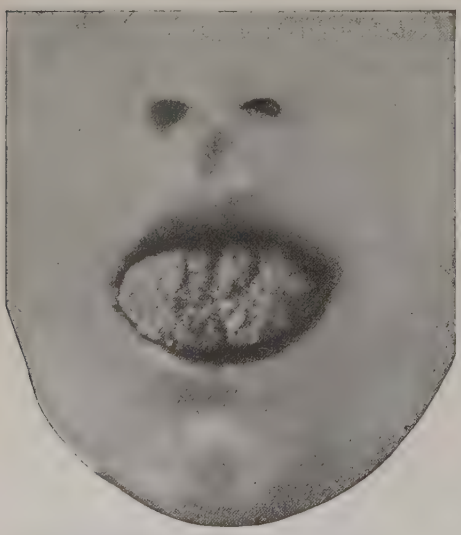
Treatment.—Although the symptoms are most distressing, and often alarming, they usually subside promptly under treatment. In cases in which the affection is only moderately developed the patient should be given an active purgative, should suck pieces of ice, and use an antiseptic mouth-wash, and under this treatment the pain and swelling will usually quickly subside. If, however, the swelling is great and increasing, and is accompanied by the symptoms previously mentioned, free longitudinal incisions should be made into the dorsum of the organ, deep enough to expose its muscular substance. These incisions are followed by the escape of blood-stained serum, and often free bleeding, but the latter subsides in a short time. After free incisions the swelling diminishes rapidly, and the patient often in a few minutes experiences great relief. An antiseptic mouth-wash should be employed until the incisions are healed.

Abscess of the Tongue.—This is an extremely rare affection, and may result from acute glossitis, from exposure to cold or heat, or from foreign bodies embedded in the tongue. The abscess may involve the central portion or the lateral aspects of the organ, and may form slowly and give rise to little pain, or may develop rapidly and be accompanied by the symptoms

of acute glossitis. **Symptoms.**—The symptoms are largely those of acute glossitis: the tongue becomes swollen and may be protruded from the mouth, swallowing and speech are difficult and painful, salivation is profuse, and the patient sits with the head bent forward, to allow the saliva to escape from the mouth and prevent painful efforts at swallowing. Sleep in the recumbent position is impossible on account of the saliva running back and causing efforts at swallowing. Upon examination of the tongue a sense of fluctuation upon palpation can generally be felt at some point. **Treatment.**—Early incision is indicated in these cases, even if fluctuation cannot be distinctly made out. A free incision should be made, and if pus does not escape, a director should be introduced into the incision and pushed in different directions through the tissues, which will usually be followed by the escape of pus. The relief of distressing symptoms is generally very prompt after the abscess is opened. After opening the abscess an antiseptic mouth-wash should be employed. In *chronic* abscess of the tongue, as soon as the location of the abscess is ascertained an incision should be made to evacuate the pus.

Chronic Superficial Glossitis.—This condition is also described as *leucoplakia*, *psoriasis*, and *ichthyosis linguæ*, affections of the tongue which are occasionally seen, and which result from chronic inflammation of the mucous membrane, with localized thickening of the epithelium. It arises from excessive smoking, from the constant introduction of irritating substances into the mouth, from the use of undiluted alcoholic beverages, and from syphilis. (Fig. 673.) It is of interest to the surgeon from the fact that if the condition is not relieved and the irritating causes are not removed there often develops persistent ulceration, which may give rise to epithelioma. **Treatment.**—This consists in removing all irritating causes, and in syphilitic cases employing mercury and iodide of potassium, with the local use of mild antiseptic mouth-washes. The diet should be regulated, and smoking and the use of alcohol interdicted. The local use of a one per cent. solution of chromic or salicylic acid is often followed by good results.

Fig. 673.



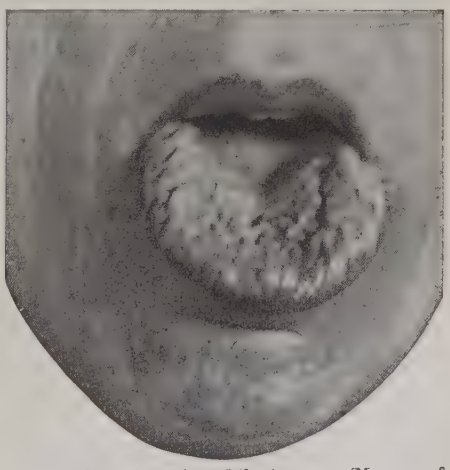
Chronic superficial glossitis. (Museum of the German Hospital of Philadelphia.)

Ulceration of the Tongue.—Ulceration of the tongue may result from wounds, burns, or scalds of the organ, or from the sharp edges of carious or broken teeth, and also from disturbance of the digestive system. The latter ulceration is often multiple, may occupy large surfaces of the organ, and is most frequently seen in children. Ulceration of the under

surface of the tongue, involving the frenum, is very common in persons suffering from whooping-cough, and is caused by the tongue being violently forced against the lower teeth. Ulceration of the tongue arising from the irritation of sharp or irregular teeth is situated at the lateral margins or the tip of the organ. A traumatic ulcer of the tongue, if it has existed for some time, is apt to be surrounded by marked induration, which may render its diagnosis from epithelioma and syphilis difficult. **Symptoms.**—Pain at first is not a marked symptom unless irritating substances come in contact with the ulcer; but if the ulcer becomes inflamed, or has existed for some time, it may cause pain upon movements of the tongue, and may render the taking of food difficult. More or less discharge is apt to occur from the ulcerated surface and causes the mouth to become foul. **Treatment.**—Ulceration due to sharp or rough teeth should be treated by filing the edges of the offending teeth, or by their removal, and the application of a ten-grain solution of nitrate of silver to the ulcer and the use of a mild antiseptic mouth-wash. The treatment of ulceration dependent upon digestive disturbance consists in the regulation of the diet and the use of remedies to improve the digestion, with the local use of a weak solution of nitrate of silver and a mouth-wash. In all cases of ulceration of the tongue the diet should consist of bland articles—a liquid diet is best—and the patient should not be allowed to use tobacco or to bring any irritating substance in contact with the ulcerated surfaces.

Lupus.—Lupus of the tongue usually exists in connection with a similar affection of the nose, face, and lips, and is rarely observed as a separate affection of this organ. **Treatment.**—This consists in thoroughly scraping the ulcers with a curette and in the application of Paquelin's cautery, at the same time antituberculous remedies, such as cod-liver oil and iodide of iron, and tonics being administered.

FIG. 674.



Tuberculous ulceration of the tongue. (Museum of the German Hospital of Philadelphia.)

Tuberculous Ulceration of the Tongue.—Primary tuberculosis of the tongue is a rare affection, but tuberculous ulceration of this organ in connection with pulmonary or laryngeal tuberculosis, or general tuberculosis, is not infrequently observed. It is rarely seen in children, being most apt to develop after puberty. (Fig. 674.) The prognosis in tuberculous ulceration of the tongue is always grave, and, as it is usually secondary to tuberculous affections of other parts of the body, its development generally hastens the fatal termination. The pain and difficulty in taking food cause the patient to run down rapidly.

Symptoms.—The disease manifests itself by the development of a nodule, usually near the tip of the tongue, which breaks down, leaving a

deep flabby ulcer with clean-cut edges and little surrounding induration. The ulcer at first may cause little discomfort, but after a time becomes very painful. The presence of tuberculous lesions in other parts of the body generally serves to differentiate this affection from gummatous and cancerous ulcerations.

Treatment.—The use of the curette and cautery in tuberculous ulcers, with the application of iodoform in some cases, appears to arrest the progress of the ulceration, but is seldom followed by healing of the ulcer. In many cases no operative treatment is indicated; here a nutritious and unirritating diet should be given, the ulcer dusted with iodoform, and mild antiseptic mouth-washes employed. As pain is usually a prominent symptom, this may be relieved by the local application of a two per cent. solution of cocaine or campho-phénique; if the patient cannot be rendered comfortable by these applications, excision of a portion of the lingual nerve or nerves may be resorted to.

SYPHILITIC AFFECTIONS OF THE TONGUE.

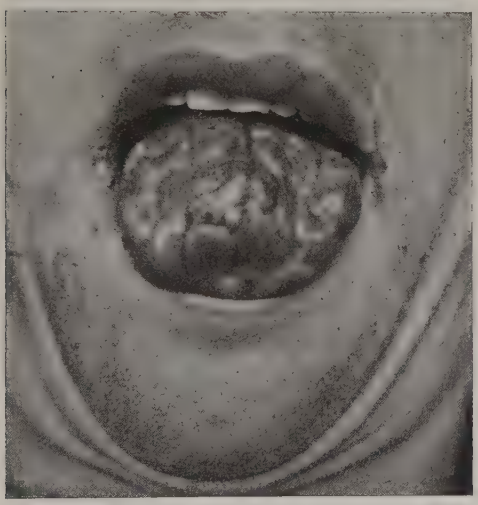
Primary syphilis or chancre of the tongue is occasionally seen. It usually starts as a small papule, which breaks down and ulcerates and presents marked induration, and is accompanied by enlargement of the submaxillary glands. Owing to the rarity of its occurrence in this situation, its specific character is often overlooked. The true nature of the affection is, however, soon demonstrated by the appearance of the secondary lesions of syphilis. **Treatment.**—This ulcer heals rapidly, and the irritation disappears under the internal use of mercury; at the same time an antiseptic mouth-wash should be employed.

Secondary Syphilis of the Tongue.—This affection may manifest itself either in the form of mucous patches or plaques or in superficial ulceration. *Mucous patches* are observed in acquired or inherited syphilis, and consist of slightly elevated, isolated, grayish patches composed of thickened epithelium, which rests upon the inflamed and swollen papillæ. They usually occupy the dorsum, tip, and lateral aspects of the tongue, but are occasionally seen upon its under surface, and generally coexist with similar patches upon the lips, cheeks, and palate. *Superficial ulceration* of the tongue is also common in secondary syphilis. The ulcers are multiple, present sharply cut edges and a grayish base, and are painful. The ulceration usually is situated upon the tip and edges of the tongue, and coexists with similar lesions of the mucous membrane of the angles of the mouth, lips, cheeks, and palate. **Treatment.**—This consists in the administration of iodide of mercury, in doses of one-quarter to one-half grain, three or four times a day, and the use of a mouth-wash of 1 to 4000 corrosive sublimate solution, or a solution of carbolic acid and chlorate of potassium, or the patches or ulcers may be painted with a 1 to 200 solution of corrosive sublimate. Under this treatment the lesions disappear rapidly. In cases, however, where the improvement is slow, the administration of iodide of potassium, from five to ten grains, combined with biniodide of mercury, one-twenty-fourth of a grain, will be followed by the most satisfactory results. Healing in these cases is often delayed by the irritation produced by the use of tobacco: so that it should be avoided.

Tertiary Syphilis of the Tongue.—The lesions of tertiary syphilis often appear many years after the primary infection, and consist of a round-cell infiltration which may result in the development of fibrous tissue, causing a sclerosed and deeply fissured condition of the tongue, or a localized accumulation may occur at some portion of the organ, giving rise to a gumma. The sclerotic process may involve the mucous membrane or the whole organ. In the early stage of the affection the tongue may be increased considerably in size, and in the later stage it becomes hard and marked by deep longitudinal fissures which extend from the tip, which is often serrated, over the dorsum of the organ. The appearance presented is very characteristic. (Fig. 675.)

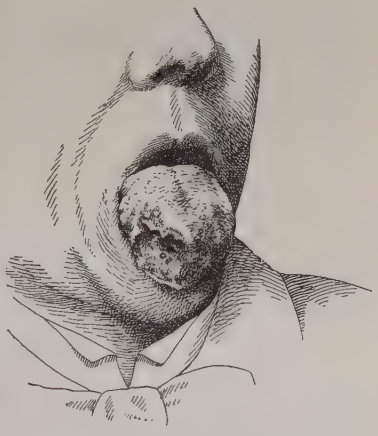
Gummata of the Tongue.—These growths arise from a localized round-cell infiltration, and are common in acquired syphilis, but are extremely rare in the inherited disease. Gummata may be superficial,

Fig. 675.



Syphilitic fissures of the tongue. (Museum of the German Hospital of Philadelphia.)

Fig. 676.



Ulcerated gumma of the tongue.

occurring in the deeper layers of the mucous membrane or in the submucosa, or they may be deep, being situated in the muscular substance of the tongue. Deep gummata are usually situated in the median line of the tongue, and can be best felt from the dorsum. They are likely to break down and give rise to a gummatous or deep syphilitic ulceration. (Fig. 676.) This, if it persists for a long time and is subjected to frequent irritation, may become epitheliomatous in character.

Treatment.—The treatment of tertiary syphilis of the tongue, either sclerotic or gummatous, consists in the use of iodide of potassium in doses of from ten to thirty grains three times a day, and in some cases the addition of biniodide of mercury, one-twenty-fourth of a grain, will be of marked benefit. In sclerosis of the tongue in the early stages, or where the parts are inflamed, the application of a lotion of chromic acid, gr. x, water, f℥i, or of a solution of nitrate of silver of the same strength, will be followed by great improvement. Under the constitutional treatment gummata may disappear

and gummatous ulcers heal promptly without much deformity resulting; but in well-marked cases of deep sclerosis, although the inflammatory symptoms may quickly subside under this treatment, the fissured and indurated condition of the part remains as a permanent deformity.

Actinomycosis of the Tongue.—This affection of the tongue is an extremely rare one, and arises from direct infection by the fungus. Microscopic examination will reveal the nature of the trouble, and the treatment consists in thorough curetting, followed by the application of the actual cautery to the surface.

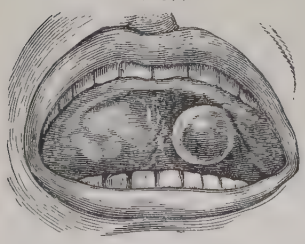
TUMORS OF THE TONGUE.

Nævus of the Tongue.—This form of vascular growth occurs upon the tongue, is generally a venous angioma, and is usually congenital except where it extends to the tongue from the floor of the mouth. It usually presents a tumor of limited extent. Nævus of the tongue presents the peculiarity that it may remain stationary for a long time, seeming to have much less tendency to increase in size than nævus in other locations. **Treatment.**—This consists in excision or ligation, but both of these methods in cases of nævus of the tongue are less satisfactory than the treatment by the actual cautery or galvano-cautery. The patient should be anæsthetized, the point of the cautery iron introduced into the tumor at a dull-red heat, and the mass of the tumor thoroughly cauterized. Little reaction follows, and one application is usually followed by a cure.

Papillomata of the Tongue.—These tumors, which may be met with at all periods of life, arise from an overgrowth of the epithelium and connective-tissue basis of the papillæ of the tongue, and usually present a pedunculated growth without surrounding induration. Papilloma of the tongue occurring during and after middle life, particularly if surrounded by induration, should be looked upon with suspicion as probably epitheliomatous. **Treatment.**—This consists in cocainizing the base of the tumor and cutting it off with scissors or the knife. If bleeding is free, the bleeding surface should be touched with a cautery iron.

Lymphangiomata, *fibromata*, *lipomata*, *adenomata*, and *cysts* of the tongue are occasionally met with, and may be congenital. (Fig. 677.) They may exist for years without producing any inconvenience, but if they cause deformity or inconvenience they should be excised. In the case of a cyst, the cyst should be dissected out or opened, its contents evacuated, and its inner surface cauterized with nitrate of silver.

Fig. 677.



Cyst of the tongue. (Agnew.)

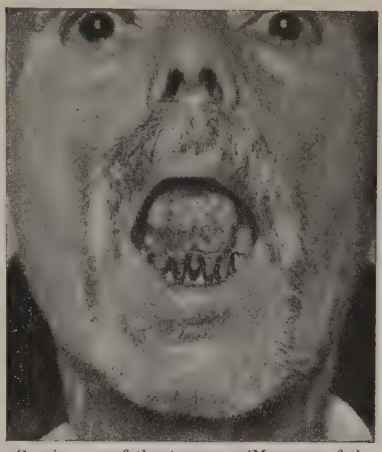
MALIGNANT TUMORS OF THE TONGUE.

Carcinoma of the tongue is quite frequent, while sarcoma of this organ is extremely rare.

Carcinoma of the Tongue.—This affection of the tongue usually commences as a fissure, nodule, or ulcer upon the margin or tip of the tongue, but may originate at any part of the organ. (Fig. 678.) Carcinoma of the tongue is one of the most dis-

tressing and painful forms of cancer, and usually proves fatal within two years, but may run a more rapid course. It is more common in males than in females, and is most frequently seen between the ages of forty-five and fifty-five. In the majority of cases some form of local irritation is the exciting cause of the disease. Smoking, the local irritation of the organ caused by alcoholic drinks, the irritation produced by the stem of a tobacco-pipe or a sharp or rough tooth, scars resulting from wounds, badly fitting tooth-plates, in fact, any local cause of irritation of the tongue, may be followed by the development of cancer of this organ. Benign growths of the tongue, if they have existed for some time, may become epitheliomatous, and the development of epithelium in a certain number of cases of leucoplakia and psoriasis linguæ has been pointed out by Butlin. Chronic ulceration of the organ arising from wounds or from broken-down gummata may also be an exciting cause of carcinoma of the tongue. There is no doubt that the continuous use of caustics applied to ulcerated surfaces upon the tongue often converts a benign ulcer into a malignant one.

Fig. 678.



Carcinoma of the tongue. (Museum of the German Hospital of Philadelphia.)

Symptoms.—The ulcer is usually a deep one, with irregular nodular edges, and is surrounded by an area of induration, but may occasionally present a fungous appearance. As soon as the ulceration is well developed there is an excessive flow of saliva and foul blood-stained discharge; pain is also a prominent symptom, and is felt in the tongue and the ear; the lymphatic glands in the submaxillary region are soon involved, and later those of the neck. The growth often extends from the tongue and involves the floor of the mouth. The infiltration and binding down of the tongue interfere with its mobility, so that speech and swallowing soon become difficult. Death results from a slow septic poisoning, from exhaustion following the constant pain, or from profuse hemorrhage if the lingual vessels are opened by ulceration, and in some cases septic pneumonia may cause a rapidly fatal termination.

Diagnosis.—All ulcerations of the tongue in patients over forty years of age should be looked upon with suspicion and should be carefully studied. Chancre and tuberculous and syphilitic ulcerations are most frequently confounded with carcinoma of the tongue. Chancre of the tongue is apt to be met with in younger subjects than those in whom carcinoma is likely to occur, and is soon followed by enlargement of the glands and the development of symptoms of syphilis. Syphilitic ulceration and gummata generally improve rapidly under the use of full doses of iodide of potassium, but constitutional syphilis does not preclude the possibility of the development of cancer in a patient having such a history, and it is a well-recognized fact that the disease sometimes develops in broken-down gummata.

Tuberculosis of the tongue is extremely rare as a primary affection, and tuberculous ulcer of the tongue is usually accompanied with tubercular lesions in other parts of the body. In cases where doubt exists as to the nature of the ulceration, a microscopical examination of a portion of the ulcer will reveal its true nature. Fixation and induration of the tongue are the most reliable diagnostic symptoms of cancer in cases of simple epithelial thickening and ulceration which have undergone epitheliomatous changes, but they occur late in the disease.

Treatment.—As carcinoma of the tongue is a most painful and distressing affection and one which is invariably fatal if untreated, operative treatment should be undertaken as soon as the diagnosis is made. The operations which are practised upon the tongue in case of carcinoma are either partial or complete excisions of the organ. Complete excision of the tongue is an operation attended with considerable danger and with a mortality of from ten to fifteen per cent. Death after this operation results from hemorrhage, shock, or septic pneumonia. In addition to the extirpation of the tongue, all enlarged and indurated lymphatic glands in the region of the tongue should be removed. The submaxillary lymphatic glands are usually involved and should be removed, and at the same time the removal of the submaxillary salivary glands has been recommended, to prevent the development of ranula from obstruction of their ducts, which is not uncommon after this operation.

Complete excision of the tongue with removal of the affected glands is sometimes followed by a permanent cure of the affection, and, even if it fails to accomplish this end, renders the patient's condition more comfortable and prolongs life, and death from recurrent disease in the glands of the neck and elsewhere is not attended with as much suffering as occurs from the primary affection. Appreciation of this fact will justify the surgeon in recommending the operation as a possible means of prolonging life and of diminishing pain and discomfort.

Cases of carcinoma of the tongue which present the following conditions, extensive involvement of the floor of the mouth, with adhesion of the tongue to it and to the jaws, involvement of the soft palate, and enlargement and induration of the submaxillary lymphatic glands and the glands situated under the sterno-cleido-mastoid, are manifestly inoperable. Operation may also be contra-indicated by the condition of the patient, as well as by the extensive development of the disease. A patient exhausted by constant suffering and who has not been able to take sufficient food, or one in advanced age, will not bear the shock of so severe an operation as excision of the tongue. In inoperable cases the pain and discomfort may be relieved in a measure by painting the ulcerated surface with a two per cent. solution of cocaine, or by the local use of campho-phénique and a mild antiseptic mouth-wash; morphine in increasing doses is sooner or later required, and may be given by the mouth or by hypodermic injection.

Excision of a portion of the *lingual* nerve, which may be reached by an incision in the floor of the mouth just below the last molar tooth of the lower jaw, has often been employed with good results as regards the relief of pain.

Partial Excision of the Tongue.—In cases where the growth is small and is situated upon the tip or edge of the anterior half of the tongue, and the submaxillary glands are not enlarged, partial excision may be practised. After partial excision, if a considerable portion of the organ is removed, the tongue is apt to be bound down by adhesions, and swallowing and speech are more or less affected; and although recurrence of the growth is no more likely to occur in the remaining portion of the tongue than in the glands or the floor of the mouth, the operation is not, on the whole, very satisfactory. Before undertaking any operation upon the tongue the mouth should be sterilized as completely as possible by the frequent use of antiseptic mouth-washes. In excising a portion of the tongue, the jaws should be separated with a gag after the patient has been anæsthetized, and two ligatures passed through the tongue near the tip, one on each side of the median line; by traction upon these the tongue is drawn out, when it is split down the centre with a knife and freed from its attachments to the floor of the mouth with scissors, and the diseased portion removed by cutting through the sound tissue well beyond the seat of the disease. The bleeding, which is free, is controlled by grasping the vessels with hæmostatic forceps, and subsequently securing them by ligatures; deep sutures may also be employed to control the bleeding. The final section of the tongue may be made with an écraseur, if the operator is not prepared to control the bleeding.

Complete Excision of the Tongue.—The immediate danger in complete excision of the tongue arises from hemorrhage, the blood escaping from the mouth or passing into the air-passages. Preliminary ligation of the lingual arteries in the neck renders the operation a comparatively bloodless one, and the incisions through which the arteries have been tied may be utilized to expose and remove the submaxillary lymphatic glands and the submaxillary salivary glands, if it is considered desirable to remove the latter. To prevent the escape of blood into the air-passages a preliminary tracheotomy should be done, and the larynx should be packed with gauze, or the lower part of the pharynx may be tamponed with a sponge. The operations which are now most frequently resorted to for the removal of the tongue are Whitehead's and Kocher's.

Whitehead's Operation.—The patient is anæsthetized, and the jaws are widely separated with a gag; a strong ligature is passed through the tip of the tongue, which is drawn forward, and the muscular attachments of the organ are divided rapidly with scissors. If the lingual arteries have not been primarily ligatured in the neck, they are tied as soon as they are cut, or before they are divided, if possible; the tongue should then be removed as near the epiglottis as possible. A strong silk ligature should be passed through the glosso-epiglottidean fold and its ends brought out of the mouth; this is to be kept in place for a few days, to enable the surgeon to draw the epiglottis and floor of the mouth forward in case of bleeding. The surface of the wound should then be dusted with iodoform, or an ethereal solution of iodoform, or compound tincture of benzoin, may be painted over it. Where it is possible, the mucous membrane should be sutured over the stump of the tongue.

Kocher's Operation.—This operation is the most satisfactory one when the floor of the mouth or the jaw is involved in the growth. A preliminary tracheotomy is performed, and the pharynx is plugged with a sterilized sponge. An incision is then made from a point just below the mastoid process, and is carried down the anterior edge of the sterno-cleido-mastoid to its middle; at this point it is carried across the neck to the hyoid bone, and from the middle of this bone to the chin. (Fig. 679.) The flap marked out by this incision is then carefully dissected up and turned upward on the cheek. The lingual and facial arteries and any large veins are ligatured; the lymphatic glands and submaxillary and sublingual salivary glands are removed. The lingual artery upon the opposite side is tied through a separate incision. The mucous membrane along the jaw and the mylohyoid muscle are next divided, and the tongue is drawn out through the incision and removed with scissors close to the epiglottis. After securing bleeding vessels, the cavity is packed with iodoform gauze, and the wound is not closed by sutures, but is allowed to heal by granulation. The most perfect drainage is secured by this method of operation, and risk of septic pneumonia is averted.

Fig. 679.

Incision for Kocher's operation.

The *after-treatment* of cases of complete excision of the tongue consists in feeding the patient for a few days by the rectum or by means of an œsophageal tube. The wound should be frequently irrigated with an antiseptic solution and loosely packed with iodoform gauze, which should be changed daily.

Results of Excision of the Tongue.—The mortality after this operation is from ten to fifteen per cent., but, although recurrence of the disease is the rule within a year in the stump, the fauces, or the glands of the neck, a number of permanent cures have been reported. The patient's life is considerably prolonged by the operation in the majority of cases, and he is generally relieved from the pain and distress which are always present in those not subjected to operative treatment.

INJURIES AND DISEASES OF THE JAWS.

Fractures and dislocations of the jaw are considered under Fractures and Dislocations.

Hypertrophy of the Gums.—The muco-periosteum which is attached to the alveolar processes of the jaws may increase so much in extent as almost or quite to cover the teeth, or the mucous membrane may be so much increased that it forms folds. This condition may be relieved by cocainizing the parts and applying Paquelin's cautery at a number of points, and where there are pendulous folds these should be excised.

Spongy Gums.—The gums may be congested, swollen, and painful, and bleed upon very slight irritation. This condition is often observed in stomatitis, in alveolar abscess, in scurvy and syphilis, and as the result of the prolonged use of mercury. The presence of this affection renders the mastication of solid food painful. **Treatment.**—This consists in the use

of astringent and antiseptic mouth-washes composed of chlorate of potassium or boric acid. The cause of the affection should be sought for and removed, and the general health should be improved by the use of tonics and a proper diet.

Alveolar Abscess.—This originates in the alveolar socket, and results from septic changes in the pulp of a carious tooth or from a dead tooth. Alveolar abscess may be superficial, and consist of a collection of pus immediately beneath the gum, when it is commonly known as a "gum-boil," or the pus may collect around the root of the tooth and find an exit by following the line of the tooth, appearing at its insertion into the gum, or by perforating the thin shell of the alveolus, and, burrowing under the muco-periosteum, appearing at various points, often some distance from its origin. In alveolar abscess originating in the upper jaw the abscess may point in the roof of the mouth or in the soft palate, in the floor of the nasal fossa, or in the antrum, while in alveolar abscess originating in the lower jaw the abscess is apt to point on the gum or on the mucous membrane between the cheek and the gum, on the cheek, or in the submaxillary region.

Symptoms.—These consist of pain of a severe and throbbing character, and of swelling of the mucous membrane in the region of the abscess and of the cheek; in the case of alveolar abscess of the upper jaw the eyelid may be swollen and œdematous, and the lymphatic glands may be enlarged and tender; at the same time febrile symptoms appear, the tongue is coated, and the breath becomes very foul.

Treatment.—As soon as the presence of suppuration is detected an incision should be made promptly to give exit to the pus, and this is usually followed by marked relief, but a sinus often persists for some time, unless the diseased or dead tooth or the necrosed portion of the alveolus is removed. In opening an alveolar abscess the incisions should, if possible, be made in the mouth, to avoid scars and persistent sinuses upon the face. After opening an alveolar abscess an antiseptic mouth-wash should be employed for a few days. If the abscess opens spontaneously upon the cheek or neck, a troublesome sinus is apt to remain until the dead bone or tooth at its bottom is removed. In cases where the pus is confined to the alveolar socket, drilling of the alveolar wall and the root of the tooth may be followed by relief. It is not always necessary to remove a diseased tooth if it is treated by a competent dentist.

Abscess of the Antrum.—Empyema of the antrum consists of a collection of pus in the antrum of Highmore, which results from suppuration in connection with the teeth of the upper jaw, injury or disease of the walls of the cavity, or extension of inflammation from neighboring cavities.

Symptoms.—Dull, aching pain, tenderness, and swelling of the gum below the antrum, with the development of febrile symptoms, and occasionally œdema and redness of the overlying skin, with obstruction of the tear-duct and escape of tears over the cheek, are symptoms often observed in this affection. The occasional discharge of pus from the nose in connection with the above symptoms is very significant. Tumors of the naso-pharynx, or those growing from the inner walls of the antrum before they have caused

deformity by expanding its walls, often present symptoms similar to those of antral abscess, and have sometimes been confounded with this affection. The most important diagnostic symptoms of abscess of the antrum are the periodical escape of pus from the nose and the presence of diseased upper bicuspid and molar teeth on the same side of the jaw. **Transillumination** has recently been employed to demonstrate the presence of pus in the antrum; this is accomplished by placing a small electric lamp in the mouth and closing the jaws, when if the antrum is in a healthy condition a translucent curved band of light appears beneath each lower eyelid, which band does not appear if the antrum contains pus; a tumor of the antrum will also interfere with the development of the band of light, so that this method of diagnosis is not absolutely reliable.

Treatment.—If a dead or carious tooth or stump is present in the region of the antrum, its removal will often be followed by the escape of pus, and free drainage may be accomplished in this way. If the teeth are not diseased, the antrum should be perforated with a bone drill through the canine fossa, and when pus escapes the wound should be enlarged and the cavity freely irrigated. At the time the antrum is opened its cavity should be explored for the presence of necrosed bone or a foreign body. The symptoms usually disappear rapidly after an opening has been made and free drainage secured.

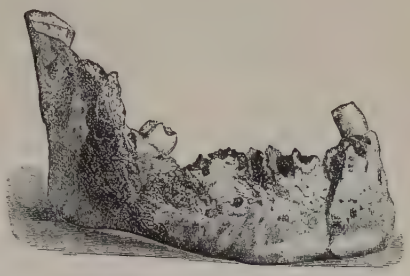
Periostitis of the Jaw.—This affection may result from injury or may have its origin in an alveolar abscess, and is frequently followed by the formation of an abscess and necrosis or caries of the underlying bone. A periosteal abscess, if allowed to run its course, will discharge sooner or later, but in the mean time causes much suffering, and necrosis is apt to occur. The symptoms of this affection are local swelling, pain, febrile disturbance, and loss of function. **Treatment.**—This consists in one or more free incisions through the swollen tissues, which should be deep enough to expose the underlying bone freely, and should, if possible, be made through the mucous membrane of the mouth, to avoid external scars. If the incisions are made promptly, the pain and swelling rapidly disappear, and necrosis of the bone and persistent sinuses may be avoided. If necrosis has already occurred, antiseptic mouth-washes should be employed, and later the necrosed bone should be removed through the mouth if possible.

Necrosis of the Jaws.—This is frequently observed after compound fractures of the jaws, as the result of periostitis or ostitis, syphilitic or tuberculous ostitis, from exposure to the fumes of phosphorus or from mercury, and is occasionally seen as a sequel of gangrenous stomatitis, measles, scarlet fever, or typhoid fever; as a result of the latter causes necrosis of a large portion of the jaws may occur. Necrosis following alveolar abscess and compound fractures is generally limited in extent, and in the former affection a thin shell of bone only is involved.

Phosphorus Necrosis.—This form of necrosis of the jaw results from the exposure of the bone to the fumes of phosphorus, which gain access to the bone by the exposed pulps of the teeth, and is usually observed in operatives in match-factories. (Fig. 680.) It has been found that persons with sound teeth can be exposed to the fumes of phosphorus without the

development of the affection. **Symptoms.**—The symptoms may not be marked at first, but swelling of the tissues over the jaws soon appears, and as a portion of the jaws becomes necrosed a shell of bone develops from the periosteum. Extensive necrosis of the jaws is the rule in these cases. In necrosis of the jaws great fetor of the breath is common, and often is the first symptom which calls attention to the condition.

Fig. 680.



Necrosis of the jaw from phosphorus. (Agnew.)

Treatment.—In cases of necrosis of the jaws it is well to wait until the dead bone has been separated from the living bone before its removal is undertaken. The patient during this time should use freely antiseptic mouth-washes of chlorate of potassium, tincture of myrrh, or permanganate of potassium, and care should be taken to provide for the free discharge of pus. When the necrosed portion of the bone is loose it should be removed: this should be done through the mouth if possible, the gum being incised as freely as is necessary, and the bone being removed by the use of an elevator and forceps. Almost the entire lower jaw may be removed through the mouth in this manner without making an external incision. If it is thought advisable, the dead bone may be divided by bone-cutting forceps and removed in sections. After the removal of the bone antiseptic mouth-washes should be employed. More or less reproduction of bone occurs from the periosteum after the removal of the dead bone, and serves to retain the shape and ultimate function of the jaw; reproduction of bone is much more marked in the lower than in the upper jaw.

Actinomycosis of the Jaw.—This affection is occasionally seen in the jaws; the fungus reaches the jaw through a carious tooth, and sets up inflammation, causing marked swelling, with implication of the surrounding tissues and the skin, being followed by the formation of sinuses and the discharge of serous or purulent fluid. An examination of the discharge in a case of this nature will reveal small yellow bodies which contain clusters of actinomyces. The lymphatic glands become enlarged, and if the disease is not arrested by prompt treatment secondary foci may develop in the lungs or the intestine. **Treatment.**—This consists in exposing the diseased tissue and removing it freely with the knife or curette, the surfaces being subsequently touched with the actual cautery.

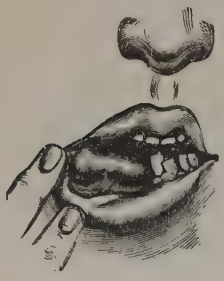
TUMORS OF THE JAWS.

Tumors of the Gums.—These are fibromata, sarcomata, epitheliomata, or papillomata. The term *epulis* was formerly applied to all tumors originating from the gums.

Fibroma (*Epulis*).—This tumor originates from the root of a carious or broken tooth, consists of fibrous tissue covered with mucous membrane, and is most frequently met with in the lower jaw. It is usually of moderate size, but occasionally may attain the dimensions of an egg and cause marked de-

formity. (Fig. 681.) The reputation for malignancy which these tumors have obtained is probably due to the fact that in the early stage it is impossible clinically to distinguish them from sarcomata. The cases in which recurrence occurred after removal were in all probability cases of sarcoma.

Fig. 681.



Epulis of the lower jaw. (Agnew.)

Sarcomata of the Gums.—These growths may occur at any age, and have been observed in infants. They originate from the muco-periosteum, and are usually of the round- or the spindle-cell variety. They may occur in either the upper or the lower gums, and project into the space between the cheeks and the teeth, or towards the palate; they grow rapidly, producing displacement of the teeth and marked change in the shape of the alveolar process of the jaw, and, if of considerable size, may protrude from the mouth.

Epithelioma of the Gums.—This growth originates in the mucous membrane covering the alveolar processes of the jaws, and is more frequent in the lower than in the upper jaw. The disease may start in the root of a carious tooth, or in a leucoplakic patch, and infiltrate the gum and extend to the floor of the mouth or cheeks, when the underlying bone soon becomes eroded. The lymphatic glands of the neck are involved early in the disease, and usually become very much enlarged. This affection runs a rapid course unless arrested by surgical treatment, and death results from septic pneumonia, or from exhaustion consequent upon the pain, the hemorrhage, and the difficulty in taking sufficient food.

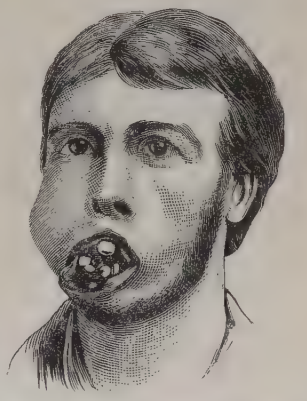
Papillomata of the Gums.—This affection is not a serious one; the papillary growths originating from the gums present the characteristic appearance of papilloma in other parts, and the affection is of especial interest only from the fact that it may be confounded with epithelioma. The slow growth, absence of pain, and the lack of glandular involvement serve to distinguish it from the latter affection.

Treatment.—The treatment of fibroma of the gums, or epulis, consists in free removal of the growth and of the root of the diseased tooth, together with a portion of the bone to which it is attached. This is best accomplished by removing one or more teeth and then excising a portion of the alveolar process of the jaw in conjunction with the tumor. Removal in this manner is seldom followed by a recurrence of the affection. In cases of *sarcoma* or *epithelioma* of the gums the diseased structures should be freely removed, together with a portion of the underlying bone, and, if the growths have not attained too large a size, the operation can be done within the mouth. The removal of these growths is, however, usually soon followed by recurrence, which, if it involves the jaw, may call for a still more extensive operation. The more promptly they are removed, the better is the chance of delaying recurrence of the disease and giving the patient a considerable period of relief from suffering. Papillary growths of the gums in persons beyond middle life should be removed as early as possible, as such growths by constant irritation may become epitheliomatous.

Osteomata of the Jaws.—These tumors consist of localized outgrowths of bone, and are more common in connection with the lower than with the upper jaw; they may originate in the alveolar process, the body, or the nasal processes of the upper jaw. They may cause more or less pain, but are principally marked by the deformity and loss of function which their presence occasions. **Treatment.**—This consists in exposing the growth by an incision, and removing it by a saw or a chisel, or by a circular saw propelled by the dental engine.

Carcinoma of the Jaw.—Carcinoma of the epithelial type may affect the jaws, and is more common in the upper than in the lower jaw. The disease first appears in the gums, and rapidly involves the bone. The lymphatic glands are affected early in the disease, and as the growth increases in size great deformity of the face results. (Fig. 682.) **Treatment.**—As soon as the nature of the growth is ascertained, its removal should be promptly accomplished, the soft parts as well as the diseased bone being freely removed. Excision of one-half of the upper jaw is often demanded in these cases. In spite of free removal of the growth, recurrence is often rapid.

FIG. 682.



Carcinoma of the upper jaw. (Mears.)

Sarcoma of the Jaw.—These growths originate in the periosteum or the bone, may occur at any period of life, and are not uncommon in young children. They grow rapidly, causing great deformity of the face, and recur quickly after removal. When originating in the body of the lower jaw (Fig. 683), they expand the inner and outer plates of the bone; in the upper jaw they usually originate in the alveolar and nasal processes. (Fig. 684.) They are of the

FIG. 683.

Sarcoma of the lower jaw. (Deaver.)

FIG. 684.

Sarcoma of the upper jaw. (Willard.)

spindle- and round-cell varieties. The former often contain tracts of hyaline cartilage, which have caused them to be classed with cartilaginous tumors.

Treatment.—This consists in the removal of the growth with a portion of the bone from which it springs. To obtain the best results the tumor should be removed as early as possible, and, if it is found that it is impossible to remove the growth completely, no operation should be undertaken. A large portion of the upper or lower jaw may be involved and require removal, and the operation, if the growth is extensive, may be attended with great risk. Many cases when they come under the care of the surgeon are inoperable by reason of their great extent. If the whole of the upper or of the lower jaw is involved, so that the complete removal of either would be required, the operation can scarcely be considered a justifiable one, by reason of the risk of the operation itself and the subsequent difficulty in taking nourishment; but if the removal of a portion only of the jaw is required, the operation is not attended with great danger, and the patient may have a considerable period of comfort before recurrence takes place. The steps of the operation are described under Partial or Complete Excisions of the Jaw.

Odontomata.—These tumors have been described in the article upon Tumors (page 87), and the greatest interest is attached to their presence from the fact that they have often been confounded with malignant growths of the jaw, and as a result of this error extensive and unnecessarily severe operations have been undertaken for their removal. The diagnosis is made from malignant tumors of the jaw by their occurrence in connection with the absence of certain teeth in young subjects, and the painlessness and slowness of their growth. **Treatment.**—As these tumors are usually encapsulated, they should be exposed, and enucleated if possible; if this cannot be done the bony wall of the tumor may be cut away, and the cavity packed with gauze and allowed to heal by granulation. In cases where the diagnosis cannot be satisfactorily made, it is wise to make an exploratory incision to ascertain the nature of the growth, and avoid the unnecessary removal of a large portion of the jaw.

TUMORS OF THE ANTRUM.

The antrum may be the seat of myxomatous, sarcomatous, and epitheliomatous growths. **Myxoma.**—These tumors are often associated with similar growths in the nasal cavities, and when numerous cause expansion of the bone and result in great deformity. **Sarcoma.**—Sarcoma of the antrum may be of the spindle- or round-cell variety, and originates in the muco-periosteum. As the growth increases in size it may extend into the nasal cavities; it may also extend downward, displacing the alveolar processes and the teeth, or upward, displacing the orbital plate. (Fig. 685.) The growth may perforate the anterior wall of the antrum and involve the cheek or the posterior wall and find its way into the spheno-maxillary or temporal fossa. **Epithelioma.**—This affection of the antrum, which occurs in patients past middle life, usually starts from the upper jaw, and is accompanied by pain, œdema of the eyelid, and infiltration of the skin over the antrum, which is finally perforated, after which a fungous growth appears upon the cheek. Extensive involvement of the subcutaneous tissue occurs at the same time. In the early stages of sarcoma or epithelioma of the antrum

the symptoms presented are often very similar to those of abscess of the antrum, and there may be considerable doubt as to the nature of the affection unless there occurs a discharge of pus from the nose.

Fig. 685.

Sarcoma of the antrum. (Mears.)

Treatment.—In cases of tumor of the antrum in which doubt exists as to the nature of the swelling, an exploratory puncture should be made through the canine fossa before undertaking any radical treatment. In cases of sarcoma of the antrum, excision of one-half of the upper jaw is the operation which gives the best results. In epithelioma the anterior surface of the antrum should be exposed by turning up a flap from the cheek, when the diseased bone and soft parts should be thoroughly removed, with any infiltrated skin which overlies the bone; if the tissues of the orbit or eyeball are involved, they should also be removed. A large, gaping wound results, which is packed and allowed to heal by granulation. The results of operation in cases of sarcoma are better than those in epithelioma; in both cases, however, recurrence is likely to take place sooner or later, but the patient's life is often prolonged and he is saved much suffering by the operation.

Deformities of the Jaws.—Congenital deformities of the jaws in connection with cleft palate, hare-lip, and median fissure of the lower jaw have already been considered (page 731). There is also very rarely observed defective development of the lower jaw, which causes the patient to present a peculiar appearance, and is associated with fixation of the jaw, rendering the use of solid food almost impossible. Acquired deformities of the jaws are not uncommon, and may result from injuries or from the contraction of the soft parts following burns or sloughing. The habit of thumb sucking in infants and children may cause a change in the shape of the jaws, as well as in the direction of the teeth. In hypertrophy of the tongue the pressure of the enlarged organ may cause a change in the shape of the jaws. **Treatment.**—In cases of acquired deformities of the jaw little can be done in the way of treatment, aside from removing the cause of the deformity, to prevent further distortion. In congenital deformities associated with fixation of the jaw, excision of the condyles or division of the neck of the condyles has been followed by an improvement in the motion of the jaw.

DISEASES OF THE TEMPORO-MAXILLARY ARTICULATION.

The temporo-maxillary articulation may be the seat of acute arthritis or of osteo-arthritis.

Acute Arthritis.—This may result from injuries, but most frequently follows the exanthemata, and is therefore most common in children. The symptoms are pain, swelling, and redness over the articulation, and if suppuration occurs the pus may come to the surface over the joint or may

escape into the external auditory meatus. In such cases necrosis or caries of the condyle and ramus of the jaw may occur. Ankylosis, either fibrous or osseous, of the affected joint is apt to occur as a result of suppuration in this articulation. **Treatment.**—This consists in obtaining rest of the articulation by securing the lower jaw firmly to the upper by means of a Barton's bandage, and at the same time counter-irritation should be made over the articulation, followed by the use of warm fomentations or of belladonna and mercurial ointment. The patient should not be allowed to talk, and should be nourished by liquid food. If suppuration occurs, an incision should be made to evacuate the pus. If caries or necrosis of the condyle of the jaw develops, the diseased bone will require removal.

Osteo-Arthritis.—This affection of the maxillary articulation is also described as rheumatoid arthritis, and is often associated with a similar affection in other joints of the body. The interarticular fibro-cartilage and articular cartilages gradually disappear, and these changes are accompanied by outgrowths of bone. The patient complains of pain and crepitation upon movements of the jaw, and a partial dislocation of the condyles may occur, producing prominence of the chin, and more or less loss of function soon results. **Treatment.**—This, as in the case of osteo-arthritis of other joints, is extremely unsatisfactory, but mild counter-irritation is often followed by relief of the pain.

Ankylosis of the Jaw.—This condition usually results from suppurative arthritis of the temporo-maxillary joint, may involve one or both joints, and may be fibrous or bony in character. The most marked symptoms are inability to open the mouth or to masticate solid food, so that the patient has to subsist upon a liquid diet. **Treatment.**—Various operations have been employed, such as division of the neck of the condyles, excision of the condyle, and Esmarch's operation, which consists in removing a wedge-shaped piece of bone from the jaw by an incision just in front of the masseter muscle, with its apex at the alveolar border. If muscular fibres or fascia can be fastened between the ends of the bone, the formation of a false joint is more likely to be secured. The object of these operations is to establish a false joint at the seat of operation. The operations which are followed by the best results are excision of the condyle and Esmarch's operation.

Closure of the Jaws.—This may be a *temporary* spasmodic affection, due to irritation of the fifth cranial nerve, causing reflex irritation of the muscles of mastication, or to the failure of the eruption of the wisdom tooth. Permanent closure of the jaws may result from ankylosis or from cicatricial contraction following ulceration or sloughing of the mouth and cheeks, and this condition not infrequently follows extensive lacerated wounds of those parts and gangrenous stomatitis. Inability to open the mouth and to masticate solid food are the prominent symptoms of this affection. **Treatment.**—In cases of closure of the jaws which have not been preceded by inflammatory symptoms it will generally be found that the condition is due to the non-eruption of a wisdom tooth, and if an examination shows that this has not appeared, an incision should be made and it should be sought for and removed; the second molar should be removed

if the wisdom tooth cannot be located. This procedure will often be followed by the relief of the symptoms.

In cases of closure of the jaws due to cicatricial contraction the division of the band of tissue, or plastic operations upon the soft parts, is usually followed by no permanent improvement; Esmarch's operation, which has been previously described, is the only procedure that is likely to be followed by a satisfactory result.

CLEFT PALATE.

This is a congenital malformation resulting from partial or total failure of union between the maxillary processes and the parietal segments. A bifid uvula is the mildest form of this malformation. In other cases the soft palate may be fissured, or both the soft and the hard palate may be separated for a certain distance, and in the most marked cases the separation may involve the whole of the soft and the hard palate and extend forward between the intermaxillary bones and the superior maxilla.

Symptoms.—Clefts of the hard palate result in free communication between the cavity of the mouth and the nasal cavities, so that in swallowing food and liquids pass into the latter cavities and often escape from the anterior nares. The voice in cases of cleft palate is indistinct, nasal, and unpleasant in character. Infants suffering with cleft palate cannot take the breast, and have to be fed with a spoon or a dropper, which allows the milk to run down into the pharynx without suction on the part of the child. Owing to the difficulty in taking food, many of these cases die of malnutrition within the first few months.

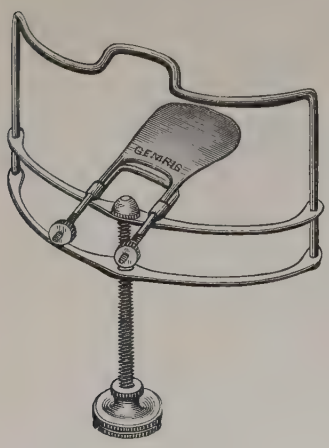
Treatment.—The most satisfactory treatment of this condition consists in performing a plastic operation, by which the edges of the cleft are freshened and brought together by sutures, so that the abnormal communication of the mouth with the nasal cavities is shut off. The same object may be attained, but we think in a much less satisfactory manner, by the fitting of a metal or a rubber obturator. This method of treatment is generally recommended by dental surgeons, but possesses the disadvantage that the obturator has to be frequently renewed, and unless it is removed and kept clean it is apt to become offensive. The operative treatment has been practised in infants, but we do not think it a wise procedure, for there is necessarily a considerable loss of blood, which is not well borne by these subjects, and the flaps are often thin and poorly nourished, so that failure of union is not uncommon. We therefore think operative treatment should be postponed until the patient is three or four years of age. The results of the operation as regards union of the flaps are always uncertain; a portion of the flaps may unite, or union may fail in the whole line from vomiting, from coughing, or from the poorly nourished condition of the flaps. Cases with wide separation with small horizontally projecting palatal processes are unfavorable ones for operation. Several operations, therefore, may be required before union is obtained in the whole line of the cleft. If after repeated operations, as sometimes happens, no union is obtained, the patient should be fitted with an obturator. The results in successful cases, as regards improvement in swallowing and relief of regurgitation through

the nose, are generally good, but the tone of the voice and the defective articulation are not often much changed; the latter, after closure of the cleft, may be much improved by systematic training. The operation is not devoid of risk, patients occasionally dying from shock, hemorrhage, or septic pneumonia.

The plastic operations which are practised to remedy this defect are *staphylorrhaphy*, which consists in freshening and uniting the edges of the fissure of the soft palate, and *uranoplasty*, which consists in a plastic operation for the closure of the cleft in the hard palate. In complete clefts of the hard and of the soft palate these operations are combined.

Staphylorrhaphy.—The patient should be anæsthetized, and the shoulders raised by a pillow so that the head falls far back; a gag should next be introduced to hold the jaws widely apart (Fig. 686.) The lower edge of the soft palate is grasped on one side with long toothed forceps, a narrow-bladed knife introduced into the tissues at the edge of the gap, and a thin strip of tissue removed. The same procedure is repeated upon the opposite side. Sutures of silk, silver wire, or silkworm-gut (the latter material is best) are next introduced through the edges of the flaps of the soft palate, with curved needles fixed in long handles and having an eye near the point. (Fig. 687.) After the needle has been passed through the tissues on one side it is threaded and withdrawn, and the needle for the other side is passed through the tissues and is threaded with the other end of the suture and withdrawn. Sutures are applied in this way until a sufficient number have been introduced to approximate the edges of the gap, when each suture is tightened and clamped with a perforated shot. Incisions are next made in the soft palate with a tenotome, to divide the palatal muscles; the knife should be entered internal to the hamular process, and made to cut upward until the muscles have been divided and the wounds gape. After the operation the patient should be

Fig. 686.



Mouth-gag.

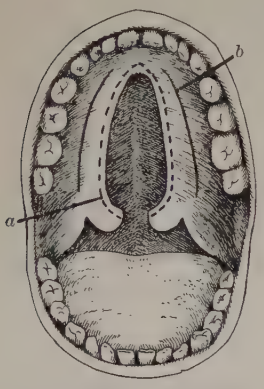
Fig. 687.

Staphylorrhaphy needles.

kept in bed for a week or ten days, being given only liquid nourishment and not allowed to talk, and the mouth being washed out after taking food with a mild antiseptic solution. At the end of ten days the sutures should be removed.

Uranoplasty.—For this operation the patient should be anæsthetized and placed in the same position as for staphylorrhaphy, and the edges of the hard and the soft palate freshened by removing strips of mucous membrane (Fig. 688, *a*); curved incisions are next made through the hard palate down to the bone on each side (Fig. 688, *b*), about one-fourth of an inch inside of the alveolar process. A periosteal elevator, curved on the flat or straight (Fig. 689), is next introduced into the incisions, and a muco-periosteal flap is dissected up; or an osteotome may be

Fig. 688.



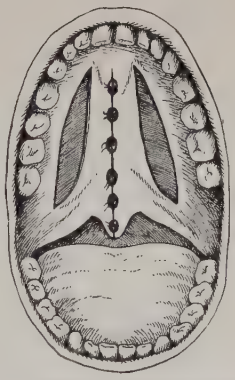
a, Incision for freshening edges of the gap; *b*, incision in the hard palate.

Fig. 689.

Periosteotomes.

introduced into the incisions and the bone freely divided, so that the detached portions with their muco-periosteal covering may be readily approximated in the line of the cleft. Sutures are next passed through the freshened edges of the hard and the soft palate as previously described, and drawn up and clamped with shot. (Fig. 690.) Free hemorrhage often occurs in both of these operations, which is usually easily controlled by pressure, but if it is severe it may be necessary to pack the incisions with gauze. Wolff's method, which consists in making incisions near the alveolar border of the gums, detaching muco-periosteal flaps, packing the wounds with gauze for a few days, and subsequently freshening the edges of the palate and uniting them with sutures, may be practised with advantage.

Fig. 690.



Edges of the palate approximated with shotted sutures; showing gaping of lateral incisions.

The after-treatment in this operation is similar to that after staphylorrhaphy, but, as a rule, the sutures should be allowed to remain for two weeks. If union occurs in a part of the cleft only, a subsequent operation may be necessary to obtain a complete closure.

Abscess of the Palate.—This may be situated in either the hard or the soft palate. Abscess of the hard palate may result from dental caries, and is usually situated just within the alveolar arch; it may also occur in connection with syphilitic or tuberculous disease of the underlying bone. The most marked symptoms of this affection are pain and swelling; the pain is often very severe; the swelling is at first firm, but soon softens. Necrosis or caries of the underlying bone is not uncommon in this affection. Abscess of the soft palate may follow acute tonsillitis. The *treatment* of abscess of the palate consists in making a free incision to evacuate the pus, after which

the cavity should be washed out with peroxide of hydrogen until the sinus is healed. If the abscess arises from a diseased tooth, this should receive treatment.

Syphilitic Affections of the Hard and the Soft Palate.—These are common in the secondary and tertiary stages of the disease. The lesions observed in secondary syphilis are mucous patches and superficial ulcerations. The chief lesions of the hard palate in tertiary syphilis are gummata, which originate either in the periosteum of the palate or in the floor of the nose, and perforate the bony roof of the palate, causing a marked change in the character of the voice, and permitting food and fluids to pass into the nasal cavities. Gummata are apt to be situated in the median line of the palate, and if they break down or are opened, more or less caries and necrosis of the bony roof of the palate occur. Gummata of the soft palate originate in the submucosa, and often result in perforation.

Treatment.—The treatment of secondary syphilitic affections of the palate consists in the use of mercury, and the local application to the mucous patches or ulcerations of a solution of nitrate of silver, gr. x to water f℥i, or of a 1 to 400 bichloride solution. The use of a mouth-wash of carbolic acid and chlorate of potassium is also followed by good results. In gummata of the palate, iodide of potassium in doses of from gr. x to gr. xv may be followed by the rapid disappearance of the tumor. If the gumma has broken down, the same treatment should be employed, and the ulcer treated by the use of mild antiseptic washes and the application of a solution of nitrate of silver.

Ulceration of the Palate.—This may involve either the hard or the soft palate, and results sometimes from operative or accidental wounds, but most commonly from syphilis. **Tuberculous** ulceration of the palate is also seen. The *treatment* of ulceration of the palate depends upon its cause. In traumatic cases the use of an antiseptic wash and the application of nitrate of silver are usually followed by good results. Syphilitic ulceration should be treated by iodide of potassium in full doses in addition to the local treatment; and in tuberculous ulceration, anti-tuberculous remedies should be employed.

Necrosis and caries of the palate may result from wounds, but are most frequently the results of syphilis. In this affection the exfoliation of the bone is very slow, and if perforation of the roof of the mouth occurs, an obturator should be worn, or the opening may be closed by a plastic operation, a flap being slid from the palate to close the gap. No operative treatment should be undertaken until the dead bone has separated and a healthy granulating surface is present.

Tuberculosis of the Palate.—Tuberculosis of the palate as a primary affection is extremely rare, but it may be associated with tuberculosis of the lungs, tongue, or pharynx, or with lupus of the nose, and may involve either the soft or the hard palate. When the soft palate is involved, disseminated tubercular nodules develop, which break down and form ulcers. In the hard palate the bone may be primarily affected, and ulceration of the palate and perforation of the roof of the mouth may occur. In tuberculosis of the palate the neighboring lymphatic glands are usually involved.

Tuberculosis of the palate, if primary, under treatment may terminate favorably, but in the majority of cases, as it is associated with tuberculosis of other parts, the prognosis is unfavorable. **Treatment.**—This consists in the use of anti-tubercular remedies, tonics, fresh air, and a change of climate. The local treatment consists in the use of mild antiseptic washes, and, if the disease is localized, curetting the ulcerated surface and painting it frequently with an ethereal solution of iodoform may be followed by healing.

TUMORS OF THE PALATE.

Sarcoma of the Palate.—This form of growth is more common in the palate than epithelioma, and its treatment should be early removal, but, unfortunately, recurrence usually takes place rapidly. **Epithelioma** of the palate may also occur as a primary growth, but generally results from extension of the growth from the mouth and tongue. The lymphatic glands are involved early in the disease. The treatment consists in early removal of the growth. **Adenomata of the Palate.**—Various forms of adenomata, adeno-fibromata, adeno-myxomata, or adeno-chondromata may be observed in the palate. The growths usually increase slowly in size. They should be removed early, and have no tendency to recur.

Nævi, as well as *mucous*, *dermoid*, and *sebaceous* cysts, may also occupy the palate. Lipomata, fibromata, and aneurisms of the posterior palatine artery and meningoceles are occasionally observed in this location. The treatment of these various lesions should be conducted upon the same general principles as for similar lesions in other parts of the body.

CHAPTER XXVII.

SURGERY OF THE NECK.

Injuries.—A simple **contusion** of the neck may be very serious, for a severe blow may compress some of the important nerves against the spinal column and produce a sudden stoppage of the heart and death without any visible injury. Hæmatoma of the sterno-mastoid muscle is frequently seen in the new-born infant, forming a fusiform swelling and causing torticollis. It usually resolves, but a permanent contraction and deformity may result. The **hyoid bone** may be **fractured** by a blow or by an attempt at strangulation. Great pain on swallowing and crepitus may be present in such cases. Union does not take place for six or eight weeks, and the suffering may be considerable. **Twists** or **sprains** of the neck cause pain and stiffness, which may be so severe as to resemble dislocation or fracture, but the symptoms of the latter are marked from the beginning, while in the case of a sprain the symptoms are worse after a few hours than at first.

Incised wounds of the neck are not common, except the extensive injuries caused by attempts at suicide by **cutting the throat**, in which cases the wound is usually upon the left side of the neck, the knife being held in the right hand. Cut-throat wounds are seldom fatal, for the great vessels generally escape division owing to their deep situation in the angle between the trachea and the spine, but the hemorrhage from the superficial veins is very serious, and the patients present a horrible appearance from the simultaneous opening of the air-passages. The wounds are generally in the neighborhood of the hyoid bone, and instances have been known in which the latter has been separated from the base of the tongue, the pharynx being opened so that three or four fingers could be passed in.

The **treatment** in these cases consists in the arrest of hemorrhage, the thorough cleansing of the parts, the insertion of a tracheotomy tube if the trachea has been opened, and the closing of the wound by a few stitches. If the pharynx has been opened it may be sutured, but the external wound should be left open in such cases to allow perfectly free drainage in case of leaking from the deeper wound. The large nerves are injured even less frequently than the main vessels. The patients are often insane and need watching afterwards. Wounds of the veins in the neck are especially liable to the complication of **aspiration of air**, producing sudden death.

Stab wounds of the neck may be as dangerous as the wide cut-throat wounds, for single nerves may be divided or small punctures made in the vessels, resulting in the production of arterio-venous aneurisms. The pneumogastric has been divided in these wounds, and also the thoracic duct.

Treatment.—A wound of this character which presents any serious symptoms should be enlarged and explored, to enable the surgeon to discover the nature of the injury and apply the proper remedy. If possible, the divided nerves should be sutured, and the thoracic duct likewise.

Gunshot wounds produce similar injuries, together with contusion and laceration of the parts, and they are very frequently fatal on account of injury of the great vessels. In stab wounds and gunshot injuries secondary hemorrhage is frequent. Extensive wounds may divide the brachial or the cervical plexus, producing paralysis. The nerves are to be sutured immediately in such cases, with due care to unite the corresponding ends.

Inflammations.—The superficial inflammations of the neck do not differ from those of other parts. **Carbuncle** is very frequently found on the back of the neck, and **boils** are exceedingly common. **Cellulitis** is quite frequent, and is very liable to interfere with respiration by direct pressure or by causing œdema of the larynx. The infectious process may also extend down into the mediastinum and cause fatal complications. It very often takes its origin in a lymph-gland, which forms an abscess and infects the cellular tissue around it. In the form of cellulitis known as **Ludwig's angina**, which is found in the floor of the mouth, the cellular tissue between the mucous membrane and the mylo-hyoid muscle becomes acutely inflamed, generally as a consequence of infection of the lymph-node over the submaxillary gland. This inflammation tends to sloughing rather than to the formation of pus, and requires very free and early incisions, because it often produces œdema of the larynx, and may result in death. The tongue is lifted up against the roof of the mouth, the mouth cannot be opened fully, and the patient can scarcely swallow or breathe.

Treatment.—The best incision for cellulitis of the floor of the mouth is one passing downward from the chin near the middle line to the hyoid bone, then curving upward towards the angle of the jaw. A semilunar flap is formed and the submaxillary gland exposed, which is pushed aside and the mylo-hyoid perforated with a blunt instrument, such as an artery forceps. If no abscess is found, but merely a dense general œdema of the parts, the tissues should be broken down in all directions by the finger, one finger of the other hand being placed in the mouth, and the two being brought together until only the mucous membrane remains between them, in order to make sure that every part of the diseased tissue has been reached. The process is frequently bilateral, and the finger can be easily pushed across the median muscles to the other side, which should also be drained by a small incision. When an anæsthetic is given in these cases preparations are to be made for tracheotomy, for these patients bear an anæsthetic very badly, as even when conscious they can hardly swallow or eject mucus or saliva from the back of the mouth. This form of cellulitis can sometimes be aborted by very early operation, the affected area being exposed by proper incisions, and the peculiar waxy indurated tissues being broken down with a blunt instrument or with the finger. Occasionally only a few drops of pus are found at the centre of this induration.

Abscesses.—Abscesses in the neck are most likely to form in the following lymphatic or cellular spaces: (1) between the larynx and trachea and

the muscles overlying them; (2) around the great vessels; (3) at the lower end of the sterno-mastoid; (4) about the submaxillary gland; and (5) between the pharynx and the vertebræ.

Retropharyngeal Abscess.—The last-mentioned, or retropharyngeal abscesses, may be acute from septic infection originating in a tonsillar abscess. They may also be chronic or tuberculous, being secondary to ostitis of the spine or to tubercular disease of the glands or tissues between the pharynx and the spinal column. They are rarely seen in adults, but are frequent in children, especially during the first two years of life. These abscesses project into the pharynx, and sometimes find their way down along the œsophagus even to the mediastinum. They may develop very rapidly. A child who has apparently been in good health may be suddenly seized with great difficulty in breathing, and examination reveals bulging of the posterior pharyngeal wall, almost entirely occluding the passage. The greatest respiratory difficulty, however, occurs when the abscess extends downward and compresses the trachea.

Treatment.—The older method of treatment consisted in opening the abscess freely in the pharynx, but this is objectionable, because the pus may enter the larynx and cause pneumonia or even suffocation. The cavity, moreover, then communicates with the pharynx, and is very likely to undergo septic infection. It is, therefore, far better to open the abscess externally, and careful examination should be made for a tumor near the larynx or up under the angle of the jaw. If fluctuation can be felt here, the abscess should be cut down upon and opened; and even if the abscess cannot be detected externally, an incision should be made on the side of the neck parallel with the sterno-mastoid, either near the angle of the jaw or on a level with the larynx, and a careful blunt dissection made just internal to the carotid. The abscess can usually be recognized by palpation with one finger in the mouth and the other finger in the wound, and when it is found a sharp-pointed pair of forceps is forced into it and the opening enlarged by separating the blades. A drainage-tube is then inserted, and recovery usually takes place in the course of a few weeks, unless bone-disease is present. In cases of emergency the abscess may be opened in the pharynx, the child being held with its head hanging down, to avoid the danger of aspiration of pus into the larynx.

Affections of the Lymphatic Glands.—The lymphatic glands of the neck are peculiarly liable to inflammation, being exposed to infection from the skin or from the mouth, nose, and ear. This infection may be acute from any of the ordinary pyogenic processes, or it may be chronic, either tubercular or syphilitic. *Pediculi capitis* are a frequent cause of enlarged glands in the neck, probably because of the opportunities afforded for infection by the constant scratching of the scalp with the finger-nails.

Tuberculous Adenitis.—The neck is a favorite situation for tuberculous glands, and they form the most common tumors of this region. A single gland may be involved, but more commonly all of a certain group are affected. The infection may enter through any tuberculous lesion on the head, and chronic affections which are not tuberculous, such as chronic eczema, catarrh, or decayed teeth, may result in tuberculous infection of the

glands, the infection in these cases passing through the local lesion and reaching the glands without rendering the local lesion tuberculous. The involvement of the glands may also be secondary to distant foci in the lung or elsewhere. Tuberculous glands are found at all ages, but are most common about puberty or soon after. (Fig. 691.) When several glands are affected, usually one or two will be larger than the rest. They vary from a pea to a walnut, and even to a hen's egg, in size, but large masses are exceptional, unless two or three glands have been fused into one. There is very commonly a periadenitis or inflammation of the cellular tissue, which renders the gland adherent to the neighboring parts, and if the node lies just under the skin the latter also becomes involved. The glands may resolve or remain stationary, or they may form an abscess. The adherent skin may become thin and of a deep purple or blue color, and when the abscess has discharged a sinus is very apt to persist. If the primary lesion is in the mouth, the submaxillary glands will be invaded. Lesions of the face, the conjunctiva, the temple, or the skin in front of the ear affect the group of glands anterior to the sterno-mastoid; while lesions of the ear itself affect those posterior to the sterno-mastoid as far back as the occiput, and lesions of the scalp affect the posterior groups of glands.

Fig. 691.

Tubercular cervical adenitis.

Diagnosis.—In the diagnosis of tuberculosis, syphilis should be excluded. Syphilitic enlargement of the glands of the neck is not common unless there is a general adenopathy. Syphilitic glands are hard and less likely to suppurate, and are more uniform in size. In elderly persons enlarged glands in the neck should excite suspicions of concealed malignant disease, and lead to a careful examination of the nose, throat, and mouth.

Treatment.—The treatment of tuberculous glands of the neck calls for much judgment. If the glands are small and freely movable, they need not be touched, but attention should be paid to the general health and to removing the cause of the infection. Iodine is usually applied to the skin in these cases, but its utility in promoting resolution of the glands is doubtful. If a gland is visibly enlarging, or if a small gland tends to break down and form an abscess, it should be excised before this occurs. If a very large number of glands are involved, the question of operation will depend upon the condition of the patient. Advanced phthisis contra-indicates operation; but if there are slight signs of tuberculosis in the lung, large masses of glands should be removed, in order to relieve the patient of the tuberculous material. The incisions chosen in the operation should be such as will leave the least evident scars. The submaxillary region may be opened by raising a flap by an incision beginning at the middle line under the chin, curving downward to the hyoid bone and then upward towards the angle of the jaw. The glands anterior to the sterno-mastoid are removed by an incision along the anterior border of that muscle, and those posterior to it are best reached

by an incision from the mastoid process downward towards the acromion along the anterior border of the trapezius. Two or more of these regions will often require operation at the same time. Very careful dissection is frequently necessary in separating the glands from the vessels and nerves. Every gland should be removed, as any that are left will enlarge later, and glands will appear even when the extirpation has seemed complete.

If the glands are too soft to be extirpated entire by the knife and scissors they should be thoroughly scraped out with a sharp curette. If a cold abscess has formed, it can often be cured by aspiration and injection of the sac with iodoform glycerin; but this should not be attempted until the entire gland has broken down, leaving only the capsule as a sac. The treatment of the sinuses left by tuberculous glandular abscesses is very unsatisfactory. A thorough application of tincture of iodine or pure carbolic acid will occasionally cure them. If this fails, the sinus should be scraped out with a sharp spoon or completely excised, the last method being generally necessary if any remains of glandular tissue exist about it.

Tumors of the Neck.—The various tumors occur in the neck, but they gain additional interest on account of the important relations which they sustain to important vessels and nerves. **Sebaceous cysts** are very common, especially upon the nape of the neck. **Lipoma** is frequent, especially in the diffuse form, and **angioma** also. (Fig. 692.) Malignant disease of the skin of the neck is a rarity; but **sarcoma** is quite common, originating from the fascia or the glands, and **secondary carcinoma** of the lymphatic glands is very common. (Fig. 693.) The **congenital tumors** of the neck have already been sufficiently described in the account of dermoid and branchial cysts. Solid tumors may also develop from these fœtal remains, especially from the so-called carotid gland—a mass of lymphatic tissue in the fork of the carotids. In making the **diagnosis** of the various tumors of the neck, due account must be taken of the rapidity of their development, the age of the patient, the various symptoms produced by their pressure upon the nerves and vessels or by their mechanical interference with respiration or swallowing, the shape and consistency of the tumor, and the extent to which the skin and the lymph-glands are involved. The diagnosis must depend chiefly upon the particular organ or tissue in which the tumor has its origin. The lymphatic glands will be found to furnish the greatest number of tumors, including simple hypertrophy.

Fig. 692.

Deep-seated non-encapsulated angioma of the neck, involving the muscles but not the skin.

The **bursæ** which normally exist between the hyoid bone and the thyroid cartilage, or above the hyoid bone between the muscles of the tongue, are liable to inflammation. A diagnosis between these bursal swellings and the cysts which originate from the thyroglossal duct may be impossible. **Sacs containing air** are found in the neighborhood of the larynx in rare cases, being produced by a sort of hernial protrusion of the mucous membrane, generally originating in the ventricles between the true and false cords. These sacs sometimes reach the size of a man's fist on forcible expiration, and can be emptied by compression. Their distention can be prevented by compressive bandages, but once formed they can be cured only by completely dissecting out the wall of the sac and ligating the pedicle which communicates with the larynx.

Fig. 693.

Carcinoma of cervical glands.

Congenital sinuses are not infrequent in the neck, occurring in the lines of the branchial clefts, which have been described in speaking of branchial cysts (page 84). These sinuses penetrate to various depths, sometimes reaching the pharynx, and then usually opening near the posterior pillars of the fauces. They cause no symptoms except a slight mucous discharge, but the annoyance may be sufficient to warrant their extirpation. It is generally impossible to destroy the epithelial lining thoroughly by cauterization, but this method of treatment may be attempted. The external orifice becomes closed occasionally, and the retained secretions decompose, inflammation is set up, and the sinus forms a chronic abscess.

THE SALIVARY GLANDS.

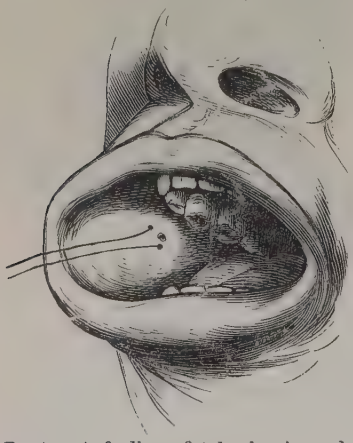
Injuries. Salivary Fistula.—**Contusions and wounds** of these glands are not important, for they heal readily and with only a temporary discharge of saliva, but a division of Steno's duct may result in a permanent **salivary fistula** opening on the surface of the skin, which is irritated by the discharge, or in a stricture of the duct. The injury to the duct is proved by the discharge of saliva from the wound or by the passage of a probe into it from the orifice of the duct in the mouth. The fistula is very difficult to cure, especially if the passage of the duct to the mouth is entirely closed.

Treatment.—An opening into the mouth is formed by passing a stout silk suture with a needle at each end from the fistula into the mouth, transfixing the entire thickness of the cheek, and tying the two ends of the ligature tightly within the mouth. (Fig. 694.) If the oral end of the duct is patent, one of the ends of the thread should be passed through it, and the other through the tissues a quarter of an inch distant. The thread slowly cuts its way through, and the epithelium follows in the track of the ligature

and renders the opening permanent. When this canal has been established the fistula will frequently close of itself, but if it should fail to do so a small flap should be cut, turned into the gap, and secured by sutures, the surrounding skin being brought together over the outside raw surface of the flap. More than one attempt to close the opening will often be necessary.

Inflammation.—The salivary glands are liable to inflammations, the most common of which is the contagious disease known as "**mumps,**" which almost invariably attacks the parotid, although the submaxillary is also occasionally inflamed. The testicles, and rarely the mammæ, are also liable to a "metastatic" inflammation at the same time as the salivary glands, and orchitis may exist alone. Mumps generally runs a course of a week or ten days, with slight fever and a rather painful swelling, frequently on both sides, although one side is often more affected than the other. The process usually ends in resolution, and suppuration is rare. **Abscesses** of the parotid, however, are not uncommon. They may be caused by direct infection from the mouth through the duct, or from some neighboring wound infecting the gland by the lymphatics. Metastatic abscesses may follow some distant process, such as osteomyelitis of the leg, puerperal endometritis, or typhoid fever. They have also been observed not infrequently as the result of gonorrhœa; but such cases may be due to direct infection of the duct by the gonococcus. Abscesses of the parotid are slow in healing, on account of the tough stroma and capsule. The **treatment** consists of very free and early incisions, but they must be made in horizontal lines parallel with the fibres of the facial nerve, so as not to injure the latter. A **chronic inflammation** of the parotid, associated with a viscid ropy saliva which blocks the duct and causes painful distention of the gland, is sometimes seen. The gland then presents a flat, board-like swelling in the cheek, and sometimes threatens to suppurate. **Treatment.**—Iodide of potassium in full doses and the passage of a probe through the duct may result in a cure, but the affection is often very obstinate. **Calculi** may form in the salivary ducts, and they are most frequent in Steno's duct, forming behind a stricture. They often have a small foreign body as a nucleus. The calculi are rough calcareous or phosphatic deposits, usually small, but occasionally of the size of a hen's egg. They cause hard smooth swellings, with very few symptoms, the principal of which is that strong pressure upon them is painful. The calculi should be removed by incision through the mucous membrane of the cheek as soon as their presence is recognized.

FIG. 694.



Treatment of salivary fistula, showing ends of deep ligature in the mouth.

Tumors.—Retention cysts of the lingual and submaxillary glands are known by the name of **Ranula**, and are considered under Diseases of the Mouth.

The most common neoplasm of the salivary glands is the so-called **mixed tumor,** which consists of fibrous tissue, fat, cartilage, and adenomatous tissue. It arises from the remains of the congenital branchial tissues, but is seldom apparent before puberty. These tumors are most common in the parotid, and grow slowly until they reach the size of an English walnut or a hen's egg, when they are apt to become stationary. They form hard rounded masses, often lobulated, sometimes almost pedunculated, standing out abruptly from the side of the face. If cysts develop in them they become elastic and grow more rapidly. The skin over them usually remains unaltered and not adherent. They may reach the size of a man's head, and when large they generally cause facial paralysis by pressure upon the facial nerve. In a certain number of cases they degenerate into sarcoma, and therefore they should be removed while they are small, if it can be done without injury to the facial nerve. They are well encapsulated, and it is not necessary to remove the surrounding tissues.

Malignant tumors appear in the salivary glands, but the parotid is more liable to both sarcoma and carcinoma than the other glands, the sublingual being almost exempt. **Sarcoma** generally develops by the degeneration of one of the mixed tumors, and therefore the tumor is of rather long duration, growing very slowly at first. **Carcinoma** appears after middle life, and forms rather flat tumors, infiltrating the entire substance of the gland and lifting the lobe of the auricle. They often occasion severe pain in the ear. The majority are rather slow in growth, but some develop rapidly. Before they are recognized they have generally involved the deepest parts of the gland, and they recur even after apparently thorough extirpation.

Treatment.—Extirpation is the only possible treatment, and in removing the parotid gland for malignant disease the facial nerve must be entirely disregarded, for every portion of the gland must be removed, including the lobe which winds around the ramus of the jaw. In order to make a complete removal of this portion of the gland and to control the dissection properly, it will generally be found necessary to cut away about half an inch of the posterior border of the ramus and of the angle of the jaw with the rongeur, after the superficial part of the gland has been dissected up and turned backward so as to uncover that portion of the bone.

THE TONSILS.

Inflammations.—The tonsils are liable to many superficial inflammatory conditions, such as follicular tonsillitis and diphtheria. Secondary syphilitic ulcers are also frequent, and in the tertiary stage gummata may form large tumors. **Abscess.**—Suppurative inflammation of the tonsil resulting in abscess, however, most frequently comes under the care of the surgeon. While the abscess may occasionally form in the substance of the tonsil, it generally lies in the cellular tissue external to the gland. The swelling is sometimes so great that the tonsil projects across the middle line of the pharynx, and the soft palate bulges forward. There are fever and great difficulty in swallowing. The pain may be severe, and the patient may be unable to open his mouth. Sometimes the condition is bilateral, adding

to the suffering. Tonsillitis is most frequent in young adults, apparently having some connection with rheumatism, and the administration of bicarbonate of sodium or of the salicylates may abort the inflammation and prevent suppuration.

Treatment.—The abscess usually points just external to the anterior pillar of the fauces, and the pus should be evacuated in that situation with a bistoury wound with plaster nearly to the point, which should be directed straight backward in order to avoid the internal carotid artery, which lies just at the outer side. The incision should be free, and cocaine may be employed if necessary. The abscess may point posterior to the tonsil, where it is difficult to reach the pus. Sometimes it is possible to evacuate the pus by passing a director into one of the lacunæ of the tonsil.

Hypertrophy.—Hypertrophy of the tonsils is a common affection in children, generally as the result of repeated attacks of inflammation. The tonsils are sometimes so large that they meet in the middle line and cause a fulness in the neck at the angle of the jaw. The child may be forced to breathe through the mouth, for the tonsils obstruct the naso-pharynx and the third tonsil is usually enlarged at the same time, and the child may acquire a peculiar idiotic appearance. The affection is most common in the so-called strumous or scrofulous diathesis, in which there is a tendency to enlargement of all the lymphatic glands. The hypertrophied tonsil may be normal in structure, but the fibrous stroma is usually more abundant.

Treatment.—Hypertrophied tonsils require removal, which may be accomplished by catching the tonsil with long toothed forceps and drawing it well out towards the median line and then slicing it off with a sharp, probe-pointed curved bistoury. A tonsillotome renders the operation easier, and the simplest form of instrument is the best. No anæsthetic is required. The hemorrhage is sometimes excessive, but is readily controlled by ice or by pressure. Pressure may be applied by a pair of forceps the ends of which are long enough to reach from the angle of the lips back to the tonsil, one branch being inserted in the mouth and the other resting on the cheek, both being supplied with broad ends and thick pads.

Small **calculi** occasionally form in the crypts of the tonsil, but seldom reach a size large enough to require an operation for their removal.

Neoplasms of the tonsil are not common, and benign growths are especially rare. **Sarcoma** forms tumors of considerable size with a tendency to spread into the adjacent soft parts, being rapid in their course. **Epithelioma** develops in the tonsil, and can be recognized by the induration, ulceration, and brittle granulations with a tendency to bleed. The tumors are usually not observed until it is too late to operate; but if the diagnosis can be made sufficiently early, and the tonsil thoroughly removed before the surrounding parts are involved, a cure can undoubtedly be effected.

Treatment.—The tonsil can be removed by Mikulicz's operation of pharyngotomy (page 788), or by splitting the cheek backward to the ramus of the jaw in the line of the mouth. These operations are to be preferred to the more extensive and mutilating methods of dividing or sacrificing large portions of the lower jaw. Large tumors should be left untouched, as it is impossible to obtain a cure.

In cases of **cut-throat** the knife may open the pharynx at the base of the tongue, sometimes making an opening into which several fingers can be passed. **Malformations** of the pharynx may produce diverticula and fistulæ, the latter passing outward in the line of the branchial clefts as already described. The diverticula resemble those of the œsophagus.

Inflammations.—The pharynx is subject to superficial inflammations of a catarrhal, diphtheritic, or rheumatic nature, which are of no particular interest to the surgeon; **tubercular** ulceration, however, is found, and **syphilitic** ulceration is exceedingly common. Extensive tubercular or syphilitic ulceration may produce great narrowing of the pharynx when the ulcers cicatrize. The soft palate is drawn backward and becomes adherent to the posterior wall of the pharynx, and the passage from the nose to the mouth may be entirely closed. This is most frequently seen in the infantile and hereditary forms of syphilis. Extensive tubercular ulceration seldom heals. Deep ulceration of the pharynx may expose the bone at the base of the skull and open the sphenoidal sinuses. The mucous membrane of the pharynx is provided with numerous deep follicles, and if a suppurative inflammation is set up an **abscess** may form external to the mucous membrane. An incision should be made as soon as the abscess can be detected. Among the syphilitic inflammations should be mentioned **gumma,** which may form tumors of considerable size in the wall of the pharynx.

Foreign bodies may become impacted in the pharynx, but they are easily removed, as a rule, by the finger or by forceps, and may be dislodged in a child by holding it head downward and shaking it vigorously.

Adenoids.—At the apex of the pharynx is a collection of lymphoid tissue in the mucous membrane which sometimes forms a considerable mass and is known as the third or pharyngeal tonsil. When this is of large size it may form a considerable obstruction to breathing. Small multiple tumors of adenoid tissue, known as vegetations, are sometimes found blocking up the vault of the pharynx. Both of these growths may be removed with a strong curette, and the soft variety scraped off with the finger-nail.

Tumors.—The **naso-pharyngeal fibrous polypi** have been described in the section on the nose. **Mucous polypi** are found in the pharynx, formed of myxomatous tissue and sometimes covered with normal mucous membrane. They are benign growths, and do not return after thorough removal by avulsion. **Congenital polypi,** in which the surface is covered by hairy mucous membrane or skin, occur, and the tumor may project from the mouth, as has been mentioned under the head of teratoma. **Malignant disease** of the pharynx is not uncommon. **Sarcoma** develops in the deeper parts of the mucous membrane and grows both externally and into the pharynx, forming tumors of considerable size, which may fill the pterygoid fossa. These tumors ulcerate quite early, and then run a rapid course with an inevitably fatal issue. The diagnosis can seldom be made in time to admit of successful extirpation. **Epithelioma** is of slower growth, and forms a superficial, ulcerating, indurated patch upon the mucous membrane, which extends slowly in different directions. It gen-

erally attacks the vault of the pharynx, and as it gives few symptoms it is not noticed by the patient until it is too late for treatment.

Pharyngotomy.—The operation of opening the pharynx is called pharyngotomy. The upper part is best reached by the **method of Mikulicz**, who makes an oblique incision parallel to the anterior border of the sterno-mastoid, beginning at the ear and extending half-way down the neck, from the centre of which an incision is carried forward, dividing the skin only. The angle of the jaw is exposed in the anterior branch of the incision, the periosteum is stripped from the bone, and the latter is divided obliquely, just above the angle, with a saw, after which the periosteum is dissected up and the ramus is seized with strong forceps and twisted out. The important vessels and nerves in the pterygo-maxillary fossa are pushed to one side and the mucous membrane of the pharynx exposed. If there has been considerable hemorrhage or shock, the wound may be packed and the pharynx not opened for several days. The operation wound is covered with granulations by that time, and the danger of infection is reduced. The pharynx having been opened, tumors of the pharyngeal wall or of the tonsil can be removed with comparative ease, especially if one finger be placed in the mouth. The deformity resulting from the loss of bone is slight, and we have found that the lateral displacement of the jaw is less than the width of one tooth. The lower part of the pharynx is opened by **subhyoid pharyngotomy**, the incision being just below and parallel with the greater cornu of the hyoid bone. The wound is deepened by careful dissection until the mucous membrane of the pharynx is reached, and the latter is incised on a line with the epiglottis, just above the larynx. This incision gives access to the upper part of the larynx or œsophagus, as well as to the lower part of the pharynx. After the operation is concluded the edges of the mucous membrane may be sutured and the external wound lightly packed, or the entire wound may be left open and the patient fed by a stomach-tube. After operations upon the pharynx the patient should be fed for two or three days by the rectum, by the introduction of a tube through the nose, or even by leaving a tube permanently in place in the wound. The last method is objectionable because of the unusual secretion of saliva and mucus excited by the tube and the increased danger of infection.

THE ŒSOPHAGUS.

Injuries.—Injuries of the œsophagus except burns or scalds are rare. **Wounds** are seldom seen, except the severe cut-throat and gunshot wounds, which generally result fatally from injury to other parts. Spontaneous **rupture** of the œsophagus has been known to occur, the contents escaping into the mediastinum. **Burns** by hot liquids or caustic substances, the most common being lye, are quite frequent, especially in children. The **treatment** consists in the administration of alkalies, vegetable acids (vinegar), and white of egg to neutralize the caustic. Rectal alimentation should be resorted to, and demulcents, of which milk is the best, given by the mouth. After the acute inflammation has subsided, the daily use of bougies is instituted, to prevent the formation of stricture.

Cicatricial Stricture.—Cicatricial narrowing of the œsophagus may follow the healing of tuberculous or syphilitic ulcers, or injury by burns or by the lodging of a foreign body in the tube. It may be annular or involve a considerable length of the tube, and it occurs most frequently near the larynx or the stomach. A stricture causes gradually increasing difficulty in swallowing until regurgitation finally results. The œsophagus above the stricture may become dilated and food may be retained for some time before it is rejected, being partly digested by the saliva in the mean time. The diagnosis from hysterical spasm or obstruction by a tumor or an aneurism may occasion some difficulty, but the history of a previous injury or of syphilitic disease is in favor of the presence of a cicatrix. Careful examination should always be made for signs of aneurism. The situation of a stricture can sometimes be determined by auscultation over the back while the patient swallows some water, a peculiar gurgle being heard instead of the gentle sound normally produced by the descending fluid. The stricture may be examined by instruments similar to those employed in the urethra—flexible bulbous and cylindrical bougies of proper length. The distance from the incisor teeth to the entrance of the œsophagus is about six inches in the adult, and to the cardiac orifice about sixteen inches. To pass the bougies the patient should be seated facing the surgeon, the head slightly bent backward, and a gag between the teeth. The surgeon depresses the base of the tongue gently with the finger, along which he passes the bougie after dipping it in warm water. The bougies should have blunt points, and must be used with great gentleness, for the œsophagus has frequently been perforated and the pleura wounded by these instruments.

Treatment.—Cicatricial strictures of the œsophagus may be treated by dilatation with bougies in the majority of cases. When the stricture has become impassable it is necessary to perform a gastrotomy either in order to feed the patient or as a temporary procedure to get a bougie through the stricture, for it is sometimes possible to pass a bougie upward from the stomach when none will go through from the mouth. If a fine bougie can be passed and a silk thread drawn through the stricture, the latter may be nicked by drawing the thread to and fro, as suggested by Abbe, and a larger bougie can then be passed. When the stricture has become fairly patent to bougies, the gastric fistula may be closed. Cicatricial strictures have occasionally been divided with instruments on the same principle as urethrotomy, but the operation is dangerous and has fallen into disuse. They may also be treated by permanent tubage. (See page 792.)

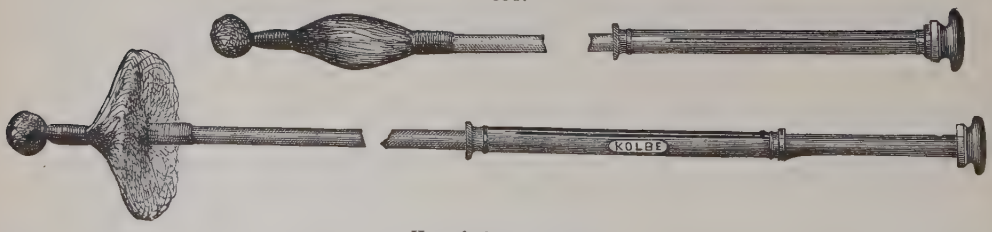
Hysterical Spasm.—Spasmodic stricture of the œsophagus most frequently occurs in women about the age of thirty or thirty-five, and is usually associated with other symptoms of hysteria, although it may be the sole sign of that condition. The spasm is sometimes caused by a reflex irritation due to the presence of wax in the ear or to some irritation of the nose or throat, and can then be remedied by correcting these conditions. In other cases no cause can be found, and a complete cure is difficult to obtain, although they generally improve under systematic dilatation. A characteristic feature of these spasmodic strictures, like those of the urethra, is that they yield more readily to a full-sized bougie with a blunt end than to a very fine and pointed

one. Relapses are very frequently seen in this condition. Besides the inability to swallow, there is occasionally a feeling of pain or constriction in the neck. The symptoms may begin suddenly or gradually. A sudden beginning, the presence of pain, the absence of an overflow of saliva from the mouth, and the coexistence of other hysterical symptoms, enable a diagnosis to be made. Cicatricial and cancerous strictures begin slowly, saliva collects above and troubles the patient by its quantity, and there is usually no pain.

Foreign Bodies.—Foreign bodies often lodge in the œsophagus, being swallowed accidentally or in jest or by the insane. The most common are coins, buttons, pieces of bone, or artificial teeth. Foreign bodies generally lodge in the narrowest parts of the œsophagus, just behind the larynx, and near the cardiac orifice. The symptoms of the presence of a foreign body are difficulty in swallowing, local pain, and sometimes a symptomatic cough, produced by the pressure of the foreign body upon the recurrent laryngeal nerve back of the larynx, resembling that heard in aneurism. The presence of a foreign body and its location can be detected by passing a bougie and feeling a metallic click or a rough object. The pharynx should always be explored with the finger. The location of the foreign body can sometimes be determined by auscultation, as in stricture. The X-ray pictures afford an excellent means of locating metallic or bony objects. An especially dangerous location is at a depth of nine inches from the teeth, as the aorta crosses at that point, and may be injured by ulceration.

Treatment.—In children the removal of foreign bodies is sometimes possible by inverting the child and making it inhale ammonia to excite strong expiratory efforts, meanwhile shaking the patient. Sometimes the passage of a plain bougie down to the foreign body or past it will dislodge it so that it will follow the instrument on withdrawal. Various instruments have been invented for the purpose of removing foreign bodies from the œsophagus, the safest of which is the horse-hair probang, which may be made to pass by the foreign body, and when withdrawn the horse-hair opens into a large disk. (Fig. 695.) The so-called coin-catcher (Fig. 696), which has a

Fig. 695.

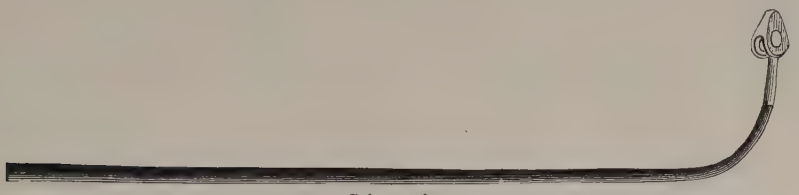


Horse-hair probang.

double shield-shaped point pivoted upon the end of the bougie, is not so safe, for sometimes it cannot be detached from the foreign body, and there may be difficulty in removing the instrument unless the foreign body is forcibly dragged up with it. Forceps can be used only when the foreign body is very high up. If the foreign body is round, so that it is not likely to injure the surrounding parts, it may be forced downward into the stomach by a blunt,

stout bougie, but this should never be done with a sharp-pointed object. When the foreign body has been in place for some days, attempts at instrumental removal become very dangerous, because ulceration may have already

FIG. 696.



Coin-catcher.

begun, as in a case in which we found during an œsophagotomy that the edge of a brass coin had perforated the œsophageal wall and lay in contact with the carotid artery one week after it had been swallowed.

Œsophagotomy.—If these attempts to dislodge the foreign body fail, œsophagotomy may be done. An incision about three inches long is made in the neck on the left side just below the level of the cricoid cartilage and parallel to the anterior edge of the sterno-mastoid. The deep fascia is opened, the sterno-mastoid and the great vessels of the neck drawn backward with a blunt retractor, and the larynx pulled towards the median line. A blunt dissection, passing well back of the larynx so as to avoid the recurrent laryngeal nerve, discloses the œsophagus lying in the depth of the wound. A large urethral sound or stout bougie should be passed by the mouth, and made to project into the wound and press the wall of the œsophagus forward so that it can be incised. The edges of the incision in the œsophagus should be at once secured by silk threads passed with curved needles. From this wound a pair of straight forceps may be passed down the œsophagus nearly to the cardiac orifice. Foreign bodies high up in the neck may be removed by a **subhyoid pharyngotomy**. (See page 788.) When the foreign body is extracted, unless it has lain a long time and caused ulceration of the wall or possibly an abscess, the incision in the œsophagus may be closed by fine sutures and the external wound lightly packed in order to guard against the chance of leakage. Food is administered by the stomach-tube or by the rectum for a couple of days. After recovery, bougies should be passed at intervals, to prevent contraction.

Diverticula are sometimes seen in the œsophagus, either as congenital malformations or as dilated pouches above a stricture, the œsophageal walls being stretched by the violent efforts at swallowing (pressure diverticula). Diverticula may also be formed by abscesses which have appeared in the neighborhood of the œsophagus and discharged into it, leaving open cavities where food lodges, or by cicatricial contraction of the tissues about the tube, which pull on a part of its wall until a sort of sac is formed (traction diverticula). These diverticula sometimes form cavities the size of a fist, with a wide or narrow mouth. The symptoms are regurgitation of food at intervals—although there may be no conscious difficulty in swallowing, and pressure upon various organs and the tube itself by the diverticulum when distended. On passing a bougie into the sac it is arrested, and the absence

of a stricture is proved by the free passage of another bougie or of food to the stomach. A cure has been obtained by dissecting out the sac, but the diagnosis and treatment of this condition are exceedingly difficult.

Tumors of the œsophagus are mainly polypi and cancer. **Benign tumors** are rare, and occur chiefly in the form of polypi of fibrous or myxomatous structure, most commonly seen in the upper part near the larynx, and sometimes slipping up into the pharynx, or even into the mouth. They are rarely multiple. Polypi seldom occasion symptoms requiring operation, but those which appear in the pharynx may be seized with forceps and removed by avulsion. The most common tumor is **epithelioma,** which develops in annular form with as much contraction as new tissue formation, resulting in the formation of a stricture unless the ulceration is extensive. Epithelioma is most usually found in the lower quarter of the œsophagus, and next in frequency near the larynx. The symptoms are those of gradually increased difficulty in swallowing, occasionally with pain shooting backward into the spine, or with a reflex cough like that caused by aneurism. Vomiting is rare, and must not be confounded with the regurgitation of food which has collected in the dilated œsophagus above the stricture. In the later stages emaciation is marked, and the patient practically dies of starvation, although there may also be severe and fatal hemorrhages, as the ulceration of the tumor may erode one of the great vessels. It may also ulcerate into the pleural cavity or a bronchus and cause empyema or pneumonia. The accessible glands in the neck are seldom enlarged, and secondary deposits are rare. The location of the stricture may be determined by the passage of a bougie, but this is attended with great risk in these cases on account of the brittle character of the œsophageal walls at the cancerous stricture, and the greatest gentleness must be employed. Endoscopic instruments have been invented for examination of the œsophagus, but the method is not yet practically useful.

Treatment.—If the diagnosis can be made very early and the tumor is high up, a radical removal is possible, and has been successfully performed. It has even been suggested to attack the lower œsophagus from behind by resecting several ribs. Life may be prolonged in hopeless cases by the use of permanent catheterization by a tube about six inches long, of the largest calibre that can be passed, and with the upper end funnel-shaped. This tube is introduced through the stricture by a special whalebone bougie and left in place, a fine silk cord being attached to it and brought out at the corner of the patient's mouth. Excellent results have been obtained by the use of these tubes in some cases, the patient gaining weight and being relieved from the danger of frequently passing the bougie. The annoyance of the string in the mouth is not very great. Where this treatment is not well borne, or the patient has not sufficient intelligence to carry it out, it may be necessary to maintain nutrition by making a gastric fistula.

THYROID GLAND.

The thyroid gland, formerly considered of little consequence, has been proved to play a very important part in the economy of the body. The gland varies greatly in size and shape in different individuals. Super-

numerary masses of thyroid tissue are sometimes found, most frequently in the middle line along the course of the thyroglossal duct or at the anterior edge of the sterno-mastoid in the situation of those branchial clefts in which the thyroid gland originated. They may also occur in the mediastinum and far out on the side of the neck, and in the case of tumors growing in any of these regions the possibility of a supernumerary thyroid should be considered. Complete atrophy of the gland is associated with myxœdema, a disease which results in impairment of the mental powers, a thickening of the subcutaneous tissue, and loss of hair; and a similar condition follows complete operative removal of the thyroid gland, with the addition in some cases of convulsions which resemble those of tetanus. Simple hypertrophy of the gland is rare, the enlargement being generally adenomatous.

Inflammation.—A congestive swelling is seen occasionally from irritation of the sexual organs, as during menstruation. Suppurative inflammation of the thyroid is rare, but it occasionally results in the formation of abscesses, although suppuration of the thyroid gland is often tuberculous in origin. In tuberculosis the gland is thickened and enlarged, the overlying skin becomes discolored, and abscesses and sinuses are formed, the course of the disease being slow but progressive. If the diagnosis could be made sufficiently early, thorough surgical treatment might result in a cure, but in no case would entire removal of the gland be permissible.

Tumors.—Tumors of the thyroid gland are common, and the great majority are histologically **adenomata,** sometimes associated with angiomatous changes of the blood-vessels. The normal gland is formed of acini without ducts, and the adenomata have the same structure, except that the acini are larger. The enlargement of the acini may be uniform throughout the gland, or one or several acini may grow more rapidly than the others and produce one or more large cysts. Sometimes one cyst will enlarge rapidly, compressing the others and converting the rest of the lobe into a thin layer resembling connective tissue, which can be recognized as thyroid tissue only under the microscope. These tumors may affect one lobe or the entire gland, and they may attain a very great size, hanging far down on the chest or extending upward at the sides of the neck. (Fig. 697.) They are known by the name of bronchocele, or goitre. Goitre is most common in Switzerland and in certain parts of Germany and England, but it frequently occurs in our native population. The cause is unknown, but the disease is endemic in certain places, and Kocher has traced it to some organic constituent of the drinking-water, for he found goitre common in certain valleys while the people of the neighboring country with a different water-supply were entirely free from it. The sporadic cases are as yet inexplicable. These tumors have very little effect upon the health in the majority of cases, even when they are of large size. In some instances they grow inward and press upon the trachea,

Fig. 697.

Thyroid tumor.

causing absorption of its cartilages, so that the softened wall is flattened and there is extreme obstruction to breathing. Goitre is found at all ages, but most commonly reaches a large size about the thirtieth year. It grows slowly, taking ten, fifteen, or twenty years to develop, and in this country we do not see the largest of these tumors.

Treatment.—Many different methods of treating adenomatous tumors of the thyroid gland have been suggested. **Iodide of potassium** in full doses has proved successful in a few cases, but only in small tumors. **Injections of iodine** into the substance of the tumor have been more successful, the tumors for which it is best suited being the soft parenchymatous growths of moderate size, for in the cysts it produces little or no effect. Churchill's tincture of iodine is used, and ten, fifteen, or twenty drops are injected directly into the substance of the gland, under conditions of absolute asepsis, the needle being passed deep into the gland, so as to avoid the large veins of the capsule. The only dangers of the treatment seem to be the infection of the tissues, with consequent suppuration, and the injection of the iodine directly into a vein, which has caused instant death. There is usually an inflammatory reaction, lasting several days and slowly subsiding, after which the gland becomes smaller and firmer.

Thyroid Feeding.—The internal administration of fresh thyroid material or extract has been recommended, and has proved efficacious in some cases, but the remedy seems to be capricious, and sometimes brings on symptoms similar to those of exophthalmic goitre.

Exposure.—Some French surgeons have recommended that instead of removing the gland the skin and the capsule should be incised and the gland turned out and left projecting in the wound, where it is said to undergo atrophy. This method leaves an unsightly scar, and there is danger of infection while the tumor is exposed, hence the operation has not become popular.

Ligature of the thyroid arteries has been tried, and with good success. The gland atrophies without sloughing, and there appears to be no danger of sloughing or myxœdema even when all four vessels are tied. But the operation is as difficult as excision, and the scars are even more extensive, so that partial thyroïdectomy still remains the most generally applicable treatment for goitre.

Thyroidectomy.—Complete removal of the thyroid gland is not allowable, on account of the danger that myxœdema may follow. Partial removal may be performed either without or within the capsule of the gland. If it is desirable to remove the lobe and its capsule, an oblique or a horizontal incision, with its centre over the most prominent part of the tumor, or an angular incision forming part of a Y, the upright of the Y beginning in the middle line at the sternum and the oblique line passing upward from the level of the cricoid cartilage towards the angle of the jaw, may be employed. The triangular flap of skin is turned back, the capsule of the gland is exposed, and any veins which cross the wound are divided between double ligatures. The tumor is bluntly dissected out. A vein will be found passing off from the upper corner of the lobe on the median side, and should be divided between two ligatures, and on the outer side will

be found the accessory superior thyroid veins, which should be similarly treated. The gland is then drawn towards the middle line, and the superior thyroid artery and vein found and included in a double ligature and divided. The inferior thyroid vessels are then sought and the vein tied first, together with the *vena ima* and any connecting branches. The inferior thyroid artery runs close to the recurrent laryngeal nerve, and therefore that vessel should be followed outward and tied near where it crosses the carotid. The gland is then pulled vigorously over towards the middle line, the capsule is divided on its posterior surface near the isthmus, and the gland is separated from its capsule working towards the isthmus. By thus leaving a part of the capsule *in situ* the laryngeal nerve is effectually protected. When the isthmus is reached it forms a natural pedicle, and an interlocking ligature is passed through it and tied like that for the pedicle of an ovarian tumor. The isolated gland is then cut away and the wound sutured. The *enucleation* or intracapsular removal of these tumors is performed by exposing the capsule of the gland by a similar incision, dividing it and deepening the incision until the real capsule of the tumor is reached. The tumor is then shelled out of the gland substance. Very few blood-vessels pass through the capsule of the tumor, and, as these are of small size, hemorrhage is readily controlled by pressure. If there is more than one tumor, the removal of the others may require a separate incision of the gland capsule. If the bleeding stops, the wound is then sutured; if not, it is to be packed.

Exophthalmic Goitre.—The disease known as Basedow's or Graves's disease or exophthalmic goitre is a peculiar affection of undetermined pathology, marked by enlargement of the thyroid, exophthalmos, rapid and irregular heart-action, and various nervous symptoms, such as tremor, hysteria, insomnia, and lack of coördination between the movements of the eyelids and the eyeballs. (Fig. 698.) The disease was formerly considered a purely medical affection, although in the well-developed cases a cure could not often be brought about by medical treatment, but the recent success in subduing the symptoms by a partial removal of the gland promises to transfer its treatment to the surgeon. Operation cures about three-quarters of the cases. The cases vary greatly in their intensity and also in their symptoms, the nervousness, the tachycardia, the exophthalmos, and the enlargement of the thyroid being found variously combined, or only two of them being present. Cases without exophthalmos or without goitre are quite frequent. While the disease has been ascribed to

Fig. 698.

Exophthalmic goitre.

various causes, such as some central nervous lesion or changes in the sympathetic nerve, the fact that it can be cured by a partial removal of the gland renders it probable that the symptoms are due to an exaggerated or improper function of the gland. There may be an oversupply of some peculiar product of the gland, or the organ may fail to eliminate from the system some toxine which it should normally dispose of. The former theory is rendered the more likely because of the close resemblance between these symptoms and those produced by poisoning with the thyroid extract, so often given now for therapeutic purposes. The changes in the thyroid gland in this disease are various, being sometimes a simple hypertrophy, sometimes a true adenoma, either parenchymatous or cystic, and sometimes changes of an angiomatous nature. It was formerly thought that operations in this condition were very dangerous, but, in spite of the rapid and irregular heart-action, comparatively few deaths are now met with. The operation to be done generally consists in a partial removal of the organ, the larger half being selected, or the tumors may be enucleated. The heart-action will usually be quieted within a short time and the nervous symptoms rapidly disappear, but the exophthalmos may persist indefinitely, although it is generally improved.

Malignant Tumors.—Malignant disease of the thyroid gland may be carcinoma or sarcoma. The tumors are rather slow in their growth at first, and the diagnosis is difficult. Carcinoma is to be suspected in cases of uniform, rather hard enlargement of the gland in persons over forty years of age. The tumors compress the trachea, and death generally results from this cause. In malignant disease the only possible treatment is complete extirpation of the gland, in spite of the danger of myxœdema or cretinism; and perhaps the administration of the thyroid extract may prevent these consequences. To be of any service the removal must take place very early. Palliative treatment is necessary in cases where the symptoms become urgent on account of the pressure exercised on the trachea by the tumor, and the gland should be divided in the middle line with the thermo-cautery, taking advantage of the natural separation of the lobes at the isthmus. It is well to note that every tumor of the thyroid which causes secondary deposits is not malignant, for adenoma has been known to occasion them in various bones, and especially in the skull. Although the metastasis of adenoma is rare, quite a number of instances are now on record.

CHAPTER XXVIII.

INJURIES AND DISEASES OF THE EYE AND ITS APPENDAGES.

Contusion and Concussion of the Eyeball.—An eyeball injured by a blow from a blunt object—for example, a fist, a billet of wood, or a cork—may present the following symptoms: discoloration of the lid, injection of the bulbar conjunctival vessels, and hemorrhage into the anterior chamber (*hyphæma*). Sometimes the cornea assumes a greenish-brown hue, owing to dissemination of hæmatodin in its layers (*blood-staining of the cornea*). Absorption of the hemorrhage is facilitated by instilling a drop of atropine and covering the eye with a light pressure bandage.

In addition to, or in place of, these lesions, there may be dilatation of the pupil (*traumatic mydriasis*), accompanied sometimes by rupture of the sphincter of the iris. The condition is not altered by treatment.

Under other circumstances the force of the blow ruptures the ciliary attachment of the iris, causing the condition known as *irido-dialysis*. As long as any signs of irritation remain, atropine drops (four grains to the ounce) should be instilled, and a light pressure bandage should be worn. Occasionally the iris will form a reattachment, but usually the false opening remains, and gives but little trouble. At times, however, it causes diplopia.

Instead of rupture of the ciliary margin of the iris the blow may be followed by displacement of this membrane, either partial or complete (*traumatic aniridia*).

Finally, contusion of the eyeball may be accompanied by *rupture of the cornea, or of the sclera*. Usually the rupture includes all the coats of the eye, as well as the conjunctival covering—that is to say, the wound is "compound;" but the conjunctiva may escape laceration and cover the torn sclera beneath it.

The immediate effect of rupture of the eyeball is extensive hemorrhage into the vitreous and the anterior chamber, associated with prolapse of the vitreous humor. Sometimes the lens escapes entirely, or lies beneath the conjunctiva. Marked reduction in tension will lead to the diagnosis of rupture of the eyeball, even when the conjunctiva is untorn and covers the wound, although in a few instances there is a similar reduction in intraocular tension merely from concussion without rupture.

The treatment of these conditions is the same as that of wounds of the eyeball, and will be considered in a subsequent section (page 799).

Traumatisms of the Crystalline Lens.—Injuries of the eyeball, either contusions or penetrating wounds, may be associated with two important results, so far as the crystalline lens is concerned:

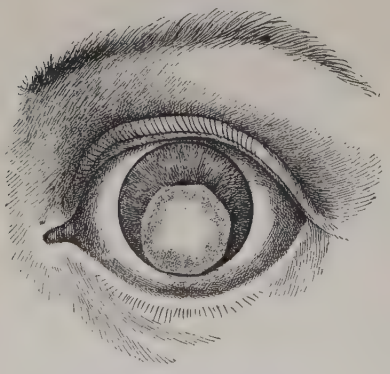
(1) **Dislocation of the Crystalline Lens.**—Luxation of the lens may be complete or incomplete. If it is partial, the margin of the lens may be seen with the ophthalmoscope as a dark line; there are tremulousness of the iris (*irido-donesis*), from weakening or rupture of the suspensory ligament, *monocular diplopia*, and *impaired power of accommodation*. A partially dislocated lens usually remains perfectly clear, and vision can be much improved by suitable glasses, operative interference being required only exceptionally.

A completely dislocated lens may be lodged in the vitreous, or in the anterior chamber, or may pass through a wound, as already stated, and lie beneath the conjunctiva, or even under Tenon's capsule.

Treatment.—A lens dislocated into the anterior chamber becomes cataractous, and by pressure upon the iris may cause inflammation, and, by occluding the angle of the anterior chamber, secondary glaucoma. It should be removed by a simple corneal incision made in the same way as for the extraction of cataract. (Fig. 699.)

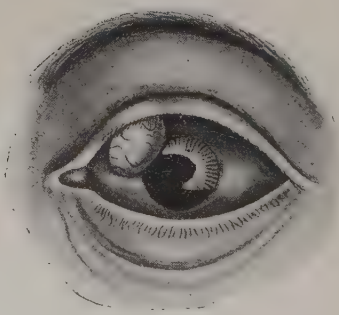
A lens lodged beneath the conjunctiva forms a rounded, somewhat translucent swelling, the overlying conjunctiva frequently being greenish or brownish in color, owing to staining with uveal pigment. The lens may be extracted through a small incision made through the conjunctiva directly over it. (Fig. 700.) A number of methods have been devised

Fig. 699.



Dislocation of lens into anterior chamber.
(De Schweinitz.)

Fig. 700.



Subconjunctival dislocation of lens.
(De Schweinitz.)

for removing a lens dislocated into the vitreous chamber. According to Knapp (and this method the author has followed), the best plan is to induce thorough local anæsthesia, make an upper corneal section, remove the speculum, and expel the lens by methodically pressing on the lower part of the sclera directly towards the centre of the eyeball. The lens will present in the pupil, and may be removed with a wire spoon in its unbroken capsule. All these manipulations require great dexterity, and are liable to be followed by escape of vitreous.

(2) **Traumatic Cataract.**—Traumatic opacity of the crystalline lens occurs either from direct or from indirect injury.

In the first instance the lens and its capsule are injured, the aqueous humor enters, the lenticular substance swells and becomes opaque. Absorp-

tion may gradually occur, or the swelling of the lens may occasion iritis, cyclitis, or secondary glaucoma, and it may be necessary at once to make a corneal section and evacuate the swollen lens material. If there is no call for immediate operative interference, the pupil should be dilated with atropine until all signs of irritation have passed away, and then the lens may either be absorbed by the operation of discission (page 828) or be extracted in the ordinary manner.

In the second instance the blow probably causes a slight rupture of the capsule, and the cataract is known as a *concussion cataract.*

Foreign bodies in the lens will be considered on page 801.

Wounds of the Eyeball.—Wounds of the eyeball may be divided into those which are superficial and non-penetrating, and those which are deep and penetrating.

Wounds of the conjunctiva are usually lacerated, and generally are situated on the bulbar expansion of this membrane.

The conjunctival cul-de-sac should be flushed with a weak antiseptic solution, preferably a saturated solution of boric acid, and the divided conjunctiva united with a few points of fine silk suture, which may be removed on the third day.

Superficial wounds of the cornea usually occur in the form of an *abrasion*, the epithelium having been scraped away by the impact of the wounding substance, for example, a finger-nail, an iron filing, or a piece of glass. Although the lesion is insignificant, it gives rise to sharp pain, marked photophobia, and copious lachrymation.

Abrasions of the cornea are important because they are frequently the starting-points of serious corneal ulceration, particularly if they have occurred in an eye in which there is some unhealthy secretion in the lachrymal passages.

Treatment.—This consists in sterilization of the conjunctival cul-de-sac with a saturated solution of boric acid or a solution of bichloride of mercury 1 to 10,000, and the application of a light sterilized pressure bandage. If there is much ciliary irritation there is no objection to a drop of atropine solution. Usually in twenty-four hours the abrasion will heal and the bandage may be discontinued.

Penetrating wounds of the eyeball may be situated in any portion of the globe, but are common at the corneo-scleral junction, or between the corneal border and the equator of the eyeball. A penetrating wound of the cornea or of the corneo-scleral junction is followed by evacuation of the aqueous humor, and generally by entanglement of the iris in the corneal wound, or by prolapse and staphylomatous bulging.

Treatment.—If the case is seen within a few hours after the accident, it is sometimes possible to replace the iris with a spatula, and by the instillation of atropine, if the wound has a central situation, or of eserine, if it has a peripheral situation, to retain the iris in place and prevent further prolapse. If, however, the iris has become firmly attached to the wound, and its surface is already covered with a layer of lymph, this procedure is not practicable. One of two methods may be adopted: the prolapsed iris may be seized, drawn forward, and abscised, as in the operation of iridectomy,

or the eye may be treated with a pressure bandage to prevent staphyloma, and atropine instilled to favor reduction of the hernia and prevent iritis.

If the wounding substance penetrates still deeper, it may lacerate the iris, the capsule of the lens, or the lens proper, and the accident is then followed by the symptoms already detailed under traumatic cataract. If the injury is not so severe as to require surgical interference, atropine should be instilled to alleviate the traumatic iritis which will follow, and iced compresses should be applied for several days.

Wounds passing through the ciliary body, or penetrating the sclera farther on towards the equator, are of much more serious nature. If the lesion has been an extensive one, and especially if infection has entered and purulent iritis has begun, sight being lost, the eyeball should be enucleated or eviscerated, to avoid the danger of sympathetic inflammation of the opposite eye. If the wound is not too extensive, and if the ciliary body is not involved and infection has not begun, an attempt should be made to save the eye by suturing the wound. First, the edges of the wound should be carefully cleansed and pencilled with a solution of bichloride of mercury 1 to 5000; then the overlying conjunctiva may be stitched in the ordinary manner, or the sutures may pass directly through the sclera. A full antiseptic dressing may be applied, or, if there is much reaction, iced compresses. These directions apply only when the surgeon has satisfied himself that there is no foreign body retained within the eye. Under the latter circumstances the treatment differs according to the directions given in a subsequent paragraph.

Burns and Scalds of the Conjunctiva and Cornea.—These are commonly inflicted with acids, lime, molten metal, flame, hot water, or steam, and are especially serious because they may be followed, particularly when lime or other caustic has come in contact with the conjunctiva, by the development of a *symblepharon*. After a superficial burn of the cornea the whole surface epithelium may be changed into a white scum. The destroyed tissue, however, is speedily replaced by a new layer of epithelium.

If lime or metal is splashed into the eye, all particles should be removed at once by flooding the eye with the water from a spigot. An acid may be neutralized with a weak alkali. The subsequent treatment calls for the instillation of an emollient, for example, castor oil and atropine drops. An excellent plan is to incorporate the atropine with liquid vaseline, which is introduced into the conjunctival cul-de-sac. Great care should be taken to prevent adhesion of the lids to the eyeball. This may sometimes be accomplished by introducing between the burned surfaces a small sheet of gold-beater's-skin.

Powder-burns of the cornea must be treated on the principles just described after the particles of powder have been removed from the corneal tissue with a spud or cataract-needle. Dr. Edward Jackson advises that each powder-grain shall be touched with the point of a fine electro-cautery needle.

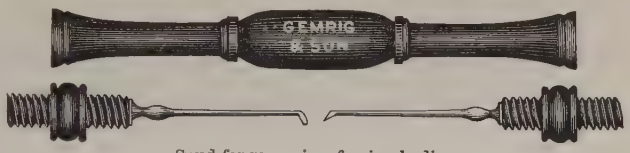
Foreign Bodies on the Cornea and Conjunctiva.—Foreign bodies usually consist of particles of sand, splinters of iron, bits of emery, or cinders, and they may lodge under the lid, in the lower cul-de-sac, or become

embedded in the substance of the cornea. Even when the body is embedded in the centre of the cornea the source of irritation is commonly referred to the under surface of the upper lid.

A patient complaining of a foreign body in the eye should be submitted to the following inspection: first the lower lid should be drawn downward and the exposed conjunctival folds examined with oblique illumination, then the surface of the cornea should be inspected with a magnifying glass, and finally the upper lid should be everted. The foreign body may be found on the surface of the conjunctiva thus exposed, but sometimes it is high up in the retrotarsal fold, and can be seen only by making the patient look strongly downward and throwing a light up into the sulcus.

Treatment.—To remove a foreign body from the cornea, after the cornea has been cocainized, the upper and lower lids are held apart with the thumb and forefinger of the surgeon's left hand, while with the right hand he takes a fine needle or spud (Fig. 701) and lifts the body from its position with as little injury as possible. Instead of using a spud, if the body is not too deeply embedded, it may be removed with an applicator on which has been twisted a wisp of cotton. It is very important to sterilize the spud, and the conjunctival cul-de-sac should be thoroughly flushed with boric acid solution after the removal of the body.

Fig. 701.



Spud for removing foreign bodies.

Foreign bodies in the anterior chamber may fall to its bottom, or may become entangled in the meshes of the iris. If there is no available wound of entrance through which the foreign body has passed, the anterior chamber should be tapped with a broad needle, and through the wound thus made a delicate pair of forceps should be passed and the body removed. If it is deeply entangled in the meshes of the iris, the portion of this membrane containing the foreign body should be withdrawn and abscised.

Foreign Bodies in the Lens.—If a foreign body penetrates still farther, it may become embedded in the lens. This accident is usually followed by cataract, either complete or rarely incomplete. If a complete traumatic cataract forms, an attempt should be made to extract the lens with the foreign body, lest the particle become dislodged and pass into the deeper structures of the eye.

Foreign Bodies within the Globe.—These usually consist of a chip of steel, a splinter of glass, a bullet, or a piece of brass filing. If the body, owing to opacities of the media, cannot be seen with the ophthalmoscope, a skiagraphic examination should be made. This in a number of instances has revealed the position of the foreign body.

Treatment.—If the surgeon has satisfied himself that there is a foreign body within the globe, an attempt may be made to extract it with delicate, carefully disinfected forceps, but only if there is some positive indication as to the direction in which to pass the forceps. If the foreign body is

known to be of iron or of steel, an attempt should be made to dislodge it with the *electro-magnet*. This is introduced either through the wound of entrance or through one made for the purpose. If the surgeon has been unsuccessful in his attempts to remove the foreign body, if he is uncertain that he has a sterile wound, and if vision is much depreciated or is lost, the eye should be enucleated or eviscerated, because sympathetic inflammation is almost sure to follow. In a few instances foreign bodies have been tolerated in the background of the eye for long periods of time, but, as Knapp states, we are never sure that they may not be the origin of serious mischief.

Injuries of the Eyelids.—Incised, lacerated, and contused wounds of the eyelids do not differ in their treatment from wounds situated in any other portion of the body. Wounds inflicted in the line of the direction of the fibres of the orbicularis result in the least visible scar, owing to the absence of gaping. There is no difficulty in securing accurate approximation of the wound, preferably with fine silk sutures.

Three results are common sequels of blows on the eye—namely, *œdema*, *emphysema*, and *ecchymosis* of the lids.

Œdema requires practically no treatment, but, if desired, an evaporating lotion—for example, dilute lead water and laudanum—may be applied.

Emphysema may follow a fracture of the orbit, which permits the air to escape into the cellular tissue through a communication with the ethmoidal or the frontal sinus.

Ecchymosis, or a collection of blood in the connective tissue, is the "black eye" of common parlance. It is also seen as the result of fracture of the base of the skull, and is, in fact, a symptom of some importance in relation to head-injuries. It may be associated with emphysema if a fracture has involved the frontal or the ethmoidal cells. Ecchymosis should be treated with applications of hamamelis, arnica, or lead water and laudanum, but not by applying leeches to the swollen lids.

Burns of the eyelids should be managed on exactly the same principles as those which are applicable to burns situated elsewhere in the body. They are important chiefly on account of the usual involvement of the cornea and conjunctiva.

Injuries of the Orbit.—These include fracture of its bony walls, penetrating wounds, the lodgement of foreign bodies, and contusions. Injury may lead to phlegmonous inflammation (orbital abscess), hemorrhage, rupture of the eyeball, or lesion of the optic nerve.

The usual symptoms of orbital disease, associated with accumulations of pus, blood, or exudate, are exophthalmos, displacement of the eyeball, diplopia, and disturbance of vision, which may finally be completely lost from atrophy of the optic nerve.

After a penetrating wound of the orbital tissues careful search should be made for the presence of a foreign body. If there has been much hemorrhage and proptosis from effusion into Tenon's capsule, it may be necessary to make incisions to evacuate the blood, lest the pressure upon the optic nerve cause blindness.

Abscess of the orbit is treated on the general principles applicable to abscess elsewhere. It is desirable that evacuation of the pus shall be

obtained at the earliest possible moment, the incisions being so placed as to avoid injuring the ocular muscles and their attachments.

After a lacerated wound of the orbit, the surgeon should carefully examine to see that the recti muscles have not been torn. If they are lacerated or detached, an endeavor should be made to suture the divided ends.

A rare injury is **dislocation of the eyeball** between the lids. If the optic nerve is not torn, the eyeball may be replaced after dividing the external commissure, which is subsequently sutured, and the eye covered with a compress bandage.

Traumatic Enophthalmos.—After a blow upon the orbit or in its immediate neighborhood, there may be marked sinking of the eyeball upon that side, giving rise to an appearance which causes the impression that the patient is wearing a badly fitting artificial eye. Cases of enophthalmos are due to cicatricial contraction of the retrobulbar connective tissue following periostitis and inflammation, to atrophy of the orbital cellular tissue, to paralysis of Müller's orbital muscle from lesion of the sympathetic, or to fracture of the orbital walls.

DISEASES OF THE EYE.

In the following pages only the most important external diseases of the eye and its appendages, together with the chief operations, are considered. The functional examination of the eye, ophthalmoscopy, keratometry, and the correction of errors of accommodation, refraction, and muscular balance are omitted. For the consideration of these the reader is referred to special treatises on ophthalmology.

DISEASES OF THE LIDS.

Abscess of the lid, the result of injury, exposure, or disease of the orbit, is not an uncommon affection, and should be treated on the principles applicable to abscess elsewhere in the body. Malignant pustule and spreading gangrene are occasionally found in the same situation.

Hordeolum, or Stye.—A stye is a furuncle, and consists in suppuration of the connective tissue in the margin of the lid. Styes may be due to errors of refraction or to constitutional derangements. They tend to recur or come in crops.

The **treatment** should consist in the vigorous application of a hot boric acid solution, or rubbing the swelling with an ointment of yellow oxide of mercury, and incision of the inflamed tissue as early as possible. The internal administration of sulphide of calcium is useful under certain circumstances. The refractive condition of the eye should always be investigated, and when necessary suitable glasses provided.

Herpes Zoster Ophthalmicus.—Herpetic vesicles may appear over the area supplied by the supra-orbital, the supratrochlear, and, more rarely, the nasal nerve. Under the last-named condition irido-cyclitis, keratitis, and even ophthalmitis may result.

The **prognosis** is always serious, and herpes zoster in this situation has not infrequently been the cause of a suppurative inflammation which has destroyed the eye itself.

The treatment should include the internal administration of iron, quinine, and arsenic. Locally, anodyne solutions are useful, particularly lead water and laudanum. Ocular complications require the same treatment as when they occur under other circumstances.

Blepharitis.—This name is applied to a variety of acute, subacute, and chronic inflammations of the ciliary border, the chief symptoms of which are the formation of crusts or scales, small ulcers at the roots of the lashes, passive hyperæmia of the lid circulation, and, if neglected, thickening of the palpebral border, together with malposition or loss of the eyelashes. In the chronic or hypertrophic type of this disease the thickened and rounded lid-border gives rise to the condition known as *lippitudo*, or "blear-eye." Blepharitis may manifest itself as an eczema (ulcerated blepharitis), a seborrhœa (non-ulcerated blepharitis), or sometimes as an acne (blepharo-adenitis). A common cause of this affection is astigmatism, and it may follow the exanthemata or disease of the nares, or may be associated with eczema, seborrhœa, or acne of the face.

Treatment.—Any anomaly of refraction should be corrected with suitable glasses. As the patients are not infrequently scrofulous, the internal administration of cod-liver oil, the hypophosphites, and hydriodic acid is advisable. The crusts should be removed with an alkaline solution, for example, bicarbonate of sodium, eight grains to the ounce, or by washing the edges of the lids with neutral Castile soap. In the eczematous varieties, a salve of yellow oxide of mercury, a grain to the drachm, is suitable; in those forms due to seborrhœa or acne, sulphur ointment (three per cent.), to which resorcin in like strength may be added; in ulcerated varieties, boric acid, aristol, and zinc ointments are useful. In cases of severe ulceration all the misplaced and stunted cilia should be removed with cilium forceps. The naso-pharynx should always be examined, and if diseased vigorously treated.

A form of blepharitis is produced when the *pediculus pubis* infests the eyebrows and eyelashes. The parasites should be destroyed by rubbing the edges of the lids and eyebrows with mercurial ointment.

Tumors and Hypertrophies of the Lid.—Cystic and solid tumors may be found upon the eyelid or its margin. Along the margin warts, or papillomata, are common, and in like situation small, clear cysts are not infrequently found.

The former should be cut off and their bases cauterized. The latter simply require puncture with a sharp needle.

A *nævus* may appear upon the lid either as a bright red spot or as an elevated, cavernous growth. It should be dealt with early in its existence, lest it spread into the orbit. When small, it may be destroyed with nitric acid. If cavernous, it may be excised, provided this can be done without causing deformity of the lid. In some instances its destruction with the galvano-cautery is better than excision. (Fig. 702.)

Other tumors found in this situation are cutaneous horns, neuromas, lipomas, adenomas, and papillomas. They should be treated on the same principles that govern the management of tumors elsewhere in the body.

Chalazion.—This is a small retention cyst, due to a chronic inflammation of a Meibomian gland, and is sometimes known as a *Meibomian cyst*, or

tarsal tumor. The tumor consists of a firm, small swelling attached to the tarsus, over which the skin is freely movable. On the conjunctival surface a discolored patch marks its position.

Treatment.—The growth may be excised through the skin layer precisely as one would remove a small sebaceous cyst, care being taken not to puncture the conjunctiva. Usually, however, it is sufficient to evert the lid, make prominent the discolored conjunctival patch, incise this with a sharp scalpel, and thoroughly curette the cavity with a small scoop. A clot of blood forms in the place of the contents of the chalazion, and is absorbed in a few days.

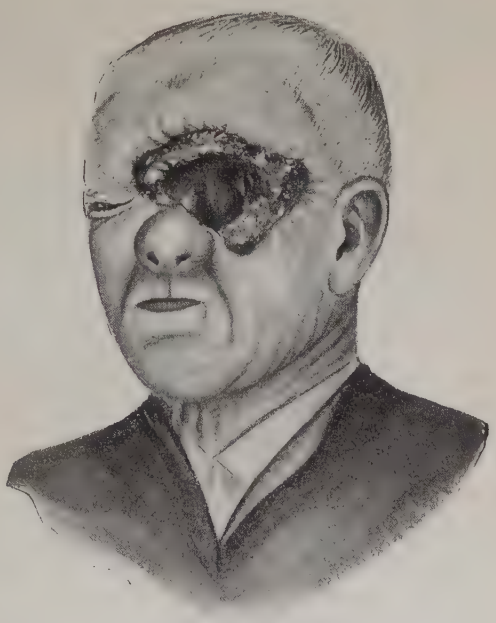
The malignant growths which may appear upon the eyelids are sarcoma, carcinoma, and lupus.

Sarcoma occurs usually in children, as a primary growth, generally at first slightly elastic, but with a tendency to rapid growth, ulceration, and involvement of the orbit. Its early removal is urgently indicated.

Carcinoma may appear as a rodent ulcer, the growth beginning as a pimple, generally on the under lid, and slowly spreading, with indurated edges, until gradually it involves not only the lid but the eye itself and the surrounding tissues. (Fig. 703.)

Instead of rodent cancer, the ordinary squamous-celled epithelioma may develop, espe-

Fig. 703.



Rodent ulcer of twenty years' standing. A case under the care of Dr. de Schweinitz in the Philadelphia Hospital.

Fig. 702.

Cavernous angioma of eyelid. A case under the care of Drs. Hearn and de Schweinitz in the Jefferson College Hospital.

cially at the angle of the eyelids, and more rarely a true glandular carcinoma appears, having its origin in the Meibomian or Krause's glands.

For epithelioma the only proper remedy is excision, and generally this necessitates an extended blepharoplastic operation. Chloracetic acid is a useful caustic in rodent ulcer.

Lupus may attack the eyelids. It requires the treatment which is elsewhere described.

Ptosis, or complete or partial drooping of the upper lid over the eyeball, may be congenital or acquired. If the condition is not remediable by medicinal measures, as, for example, is syphilitic oculo-motor palsy, an operation may be needed to remedy the defect. The simple operation of removing an elliptical portion of the skin of the drooping lid, together with the hypertrophied subcutaneous fat and connective tissue, is practically useless, although often practised.

Numerous operations have been devised for the purpose of relieving ptosis, some of the best being those which endeavor to connect the tarsal portion of the lid to the anterior portion of the occipito-frontalis muscle.

Lagophthalmos, or inability to close the eyelids, which may be either non-paralytic, or paralytic, as, for example, after facial palsy, may be corrected by the operation of *tarsorrhaphy*, which consists in freshening the edges of the lids at the external commissure for a distance of about five millimetres, care being taken not to destroy the hair-bulbs. The edges are then approximated with silk sutures.

Symblepharon, or a cohesion between the eyelid and the eyeball, has been referred to in connection with burns of the cornea and the conjunctiva. It may also follow severe types of conjunctivitis.

In simple symblepharon it is sufficient to divide the adherent bands, but if it is extensive an operation must be devised which shall cover in the denuded surfaces. The one recommended by Mr. Teale is the best. In this, after the bands have been divided, flaps of conjunctiva from the neighboring portions of the eyeball are slid into place and attached with sutures. The author in some cases of extensive symblepharon has prevented reattachment of the lid to the ball by planting upon the denuded surface an ordinary Thiersch graft.

Trichiasis is an affection in which the eyelashes are misplaced and turned inward against the eyeball. If there are several rows of cilia, the name *distichiasis* is applied. The usual causes of trichiasis are chronic inflammatory conditions of the lids, especially trachoma and blepharitis. Sometimes the affection is congenital.

If the misplaced lashes are not too numerous, they may be removed with an ordinary epilating forceps, and in order to prevent the recurrence of the disease each follicle may be destroyed with the fine point of an electro-cautery needle. If the condition is associated with entropion, as is commonly the case, some form of single or double transplantation of the entire ciliary border is usually required. (See next paragraph.)

Entropion, independently of that variety which is often caused by a spasmodic contraction of the orbicularis in inflammatory conditions of the eyelids and conjunctiva, usually consists of an organic inversion of the lid border, associated with malposition of the lashes. For its relief numerous operations have been advised.

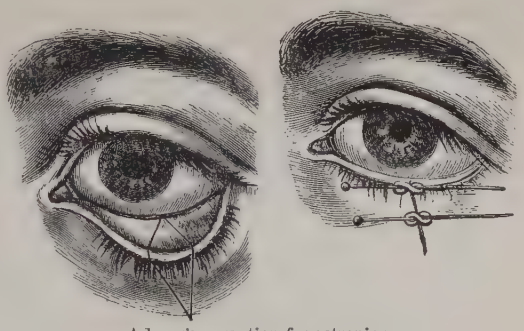
Treatment.—The author prefers the *method of Hotz* for reconstruction of the upper lid border. In this operation the ciliary border is split by an intermarginal incision to a depth of three or four millimetres. Next a transverse incision is made through the lid skin and the orbicularis muscle, just below and parallel with the upper line of the tarsal cartilage, the edge

of which is exposed. The lid skin is now united with the upper border of the cartilage by means of three sutures, each suture passing through the edge of the skin, then through the upper border of the cartilage, and finally through the upper edge of the skin wound. When these sutures are tied, the lid skin is drawn upward and fastened to the upper border of the tarsus. This causes a gaping of the intermarginal incision in the form of a groove, which is now filled with a long graft of skin, preferably taken from behind the ear. This graft is spread out and gently pressed into the groove, no sutures being necessary. The dressing should consist of a pad soaked in sterilized salt solution.

Ectropion is the opposite condition—namely, an eversion of the lid, with exposure of the conjunctival surface. It may result from diseases of the conjunctiva and the margin of the lid, from palsy of the facial nerve, from wounds, and particularly from burns and subsequent cicatricial contraction, or from caries of the malar bone and the margin of the orbit.

Treatment.—In all organic varieties some plastic operation must be devised which will restore the everted lid. In the space allotted it would be impossible to describe the numerous blepharoplastic methods which are in vogue, most of which consist in excision of the cicatrix and sliding flaps into place to cover in the defect. Sometimes it suffices to excise a V-shaped piece of the lid, as in the operation which was devised by Adams. (Fig. 704.)

Fig. 704.



Adams's operation for ectropion.

When the cicatrix is extensive the gap produced by its excision must be covered by a flap of skin taken from the forehead, the nose, or the cheek. To obviate the resulting scars of extensive plastic operations the Lefort-Wolfe flap, or, in other words, transplantation of skin without a pedicle, may be tried. The flap in all instances should be at least one-third larger than the spot which it is intended to cover. Thiersch grafts may be used to cover granulating surfaces or small defects.

DISEASES OF THE CONJUNCTIVA.

Inflammatory conditions of the conjunctiva are generally described under the name *conjunctivitis*, which is synonymous with the *ophthalmia* of the older writers. Three chief varieties may be mentioned.

Simple or catarrhal conjunctivitis, which is common in warm and changeable weather, causes an injection of the posterior conjunctival vessels, œdema of the conjunctiva, and a free muco-purulent discharge. It is distinctly contagious, and when breaking out in schools or barracks may become a serious affection, one variety, the so-called *epidemic conjunctivitis*, vulgarly known as "pink-eye," almost certainly depending upon a small

bacillus discovered by Dr. John Weeks, of New York, or sometimes on the pneumococcus of Fraenkel. The prognosis is good.

The **treatment** consists in frequent washing of the lids with tepid water and Castile soap, the instillation of a saturated solution of boric acid, and, if the discharge is free, painting the tarsal conjunctiva with a solution of nitrate of silver, five grains to the ounce. The nasal mucous membrane, which is almost always associated in the inflammation, should be sprayed with a mild antiseptic solution.

Purulent Conjunctivitis.—This manifests itself in two chief forms:

Purulent Conjunctivitis of New-Born Children, or **Ophthalmia Neonatorum.**—This disease depends upon an infection of the eyes during birth, and in virulent forms is always due to the presence of the gonococcus of Neisser. Nearly always both eyes are affected, and usually the disease begins on the third day after birth, although it may be delayed until the tenth or the twelfth day, especially if the infection is secondary.

The symptoms are those of a violent conjunctivitis—namely, great swelling of the mucous membrane, œdema of the lid, and the free secretion of thick creamy pus, which is highly contagious. The nutrition of the cornea is always threatened, and frequently ulcers form, so that if the disease is neglected or badly treated extensive sloughing of the cornea may occur, with destruction of sight, owing to perforation of the ulcers and the formation of adherent cicatrices, which later bulge and produce the condition known as staphyloma of the cornea.

The **treatment** is both preventive and curative. The *preventive treatment* consists in all measures which are known to modern antiseptic midwifery, and particularly in infected cases the method of Credé, which consists in dropping one drop of a two per cent. solution of nitrate of silver in each eye immediately after birth, the lids being subsequently covered with small compresses soaked in a solution of salicylic acid. It is not necessary to repeat this instillation.

The *curative treatment* comprises three measures: *first*, during the inflammatory stage, the local application of cold, which may be applied with small compresses of lint thoroughly chilled by being placed upon blocks of ice, from which they are transferred to the closed lids, and renewed as often as may be necessary to keep up a uniform cold impression. *Second*, scrupulous cleanliness, the conjunctival cul-de-sac being irrigated every ten or fifteen minutes with a saturated solution of boric acid, or a solution of bichloride of mercury 1 to 10,000, or of formalin 1 to 3000. *Third*, nitrate of silver as soon as the discharge is free and creamy, applied by dipping a small mop of absorbent cotton into a solution ten grains to the ounce (or twenty grains to the ounce), and carefully touching the swollen mucous membrane of the everted lids, subsequently neutralizing the excess by flooding the surfaces with a saline solution, and continuing the application of the saline solution until the white scum which follows the application of the silver has been washed away and the mucous membrane resumes its red appearance. The lids should then be greased with pure white vaseline, some of which should be introduced within the conjunctival cul-de-sac. If ulcers form, it may be necessary to instil a weak solution of atropine, two

grains to the ounce, or in some instances, if the ulcer is peripheral in situation, of sulphate of eserine, one-sixth of a grain to the ounce.

If the cornea becomes hazy and its nutrition is depressed, the local application of very hot compresses, at a temperature of 120° F., may replace the iced cloths. These hot compresses are useless unless the temperature mentioned is maintained.

The *prognosis* of ophthalmia neonatorum is always grave, but if the case is seen early, while the cornea is still bright, active medication such as described should be efficacious. A few instances appear to possess an inherent malignancy, and in spite of treatment the cornea sloughs. The same is true of cases which assume a diphtheritic type.

Gonorrhœal conjunctivitis is the purulent inflammation of the conjunctiva which occurs in adults when either from an active gonorrhœa or from a gleety discharge infection has been transferred to the eye. Unlike ophthalmia neonatorum, it is more apt to be unilateral, and the right eye is affected more commonly than the left.

The symptoms are similar to those of ophthalmia neonatorum, but even more aggravated than in this affection. Gonococci are always freely present, and in every case of purulent discharge from an eye in an adult the pus should be examined for the presence of these micro-organisms.

Treatment.—This is exactly the same as that detailed for ophthalmia neonatorum, the only difference being that the measures may be more vigorous because the patients are adults. In addition to the antiseptic lotions already named, in recent times, free irrigation of the conjunctival cul-de-sac with a solution of permanganate of potassium 1 to 2000 has been advocated. This irrigation should be done twice a day, and not less than a litre used on each occasion, the drug being introduced beneath the lids by means of a special laveur.

If there are much œdema of the conjunctiva and much swelling of the lids, there is no objection to division of the external commissure, and even, in bad cases, to splitting of the lids to prevent the deleterious effects of pressure.

The prognosis is essentially grave, even under the most advantageous circumstances, while ulcers of the cornea, abscesses of this tissue, and, indeed, extensive purulent keratitis, are the common results of neglected or badly treated cases of gonorrhœal conjunctivitis. If one eye alone is affected, the other may be protected with a watch-glass, applied in the manner illustrated in Fig. 705. This is called Buller's shield.

Fig. 705.

Buller's shield.

Granular Conjunctivitis (Trachoma, Granular Lids).—This disease occurs in two forms, either as an acute granular conjunctivitis, which is a disease having the symptoms

of acute conjunctival inflammation, associated with the formation in the tarsal and less commonly in the bulbar conjunctiva of small bodies or granules, the so-called *trachoma bodies;* or in a chronic form—the usual type—which may be the final stage of an acute variety, or result without such antecedent condition.

In chronic trachoma, especially in the upper and lower retrotarsal folds, rounded granulations appear, which from fancied resemblances have been called sago-grain, frog-spawn, and vesicular granulations. According to one school, they should be regarded as new-formed pathological products analogous to a lymphoid structure. According to another school, they are simply the overgrowth of the natural lymphatic follicles of the part.

Trachoma is common in certain races, particularly the Jews, Italians, Poles, and inhabitants of the East; it is almost unknown in pure negroes. The disease is disastrous if it breaks out in barracks, homes, or armies. The affection is contagious, especially when secretion is marked, and in one sense specific—that is, the secretion of an infected eye when introduced into another eye will produce a like affection. It is due to a micro-organism, or perhaps to parasitic protozoa.

There are many varieties of granular lids, the most common being (*a*) *follicular trachoma*, analogous to the so-called follicular conjunctivitis, in which there is a hypertrophy of the natural follicles of the part; (*b*) *papillary trachoma*, in which the trachoma bodies are hidden among the swollen papillæ of the conjunctiva; and (*c*) *cicatricial trachoma*.

As the trachoma bodies increase, they press upon one another, softening occurs, discharge becomes more manifest, new bodies take the place of old ones, and so the process goes on, until finally the conjunctiva and sometimes even the deeper tissues of the lid are converted into scar-tissue. Contraction causes the lid to be deformed and its border inverted, or, in other words, entropion and trichiasis develop. Owing partly to the rough surface of the lids and partly to a special implantation of the disease in the corneal layers, the common sequel is the development of new-formed blood-vessels in the superficial layers of the cornea, associated with roughening and sometimes ulceration of its surface. This is *pannus*, which may be slight, or dense and fleshy in consistence.

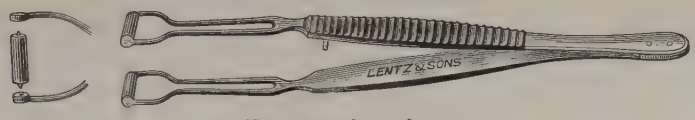
Treatment.—The treatment of acute granular conjunctivitis is the same as that of any other acute inflammation of the conjunctiva.

The treatment of the chronic variety of granular lids is medicinal and surgical. Almost all astringent and caustic applications have been employed. The following are the best: in the stage of papillary hypertrophy with much discharge of muco-purulent material, nitrate of silver, to be applied in the manner already described, ten or fifteen grains to the ounce; in the stage of lymphoid infiltration with a tendency to exuberance of the granulations, strong solutions of bichloride of mercury, 1 to 500, applied to the everted lids precisely as is the silver solution with a cotton mop or camel's-hair brush; and in the stage of beginning cicatrization, or at any time when purulent discharge is absent, the local application of a smooth crystal of sulphate of copper. In mild types of chronic granular lids, especially when there is a tendency to drying of the epithelium, tannin and

glycerin, from thirty to sixty grains to the ounce, or boroglyceride, from twenty to thirty per cent., are excellent applications.

Of the numerous surgical measures which have been devised from time to time, in the experience of the writer Dr. Knapp's *expression operation* is the best. The patient being etherized, the lids are everted, and all the granulations and lymphoid infiltration are thoroughly expressed by rolling the diseased surface with a pair of forceps constructed on the principle of a mangle. (See Fig. 706.) During the rolling process the lids are kept

Fig. 706.

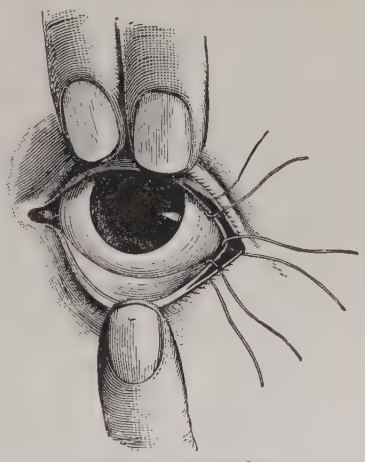


Knapp's trachoma forceps.

flooded with a tepid solution of bichloride of mercury 1 to 5000, and at the expiration of the operation they are covered with frequently changed cold compresses. Great care must be taken to prevent adhesions. The subsequent treatment of the case is the same as that of any ordinary conjunctivitis—first, nitrate of silver, and later a more active astringent, for example, sulphate of copper.

Pannus will usually subside with the disappearance of the granulations. If it does not, it must be treated like a vascular keratitis, with atropine or eserine. In severe cases the vascular supply of the cornea may be stopped by the operation of *peritomy*, which consists in dividing the conjunctiva in a circular manner around the margin of the cornea, about two millimetres from its edge.

Fig. 707.



Operation of canthoplasty.

If the palpebral fissure is too short, it may be enlarged by the operation of *canthoplasty*, in which the external commissure is divided and a flap of conjunctiva is attached to the skin margins, in the manner illustrated in the accompanying cut. (Fig. 707.)

Of the remaining types of conjunctivitis, two deserve special mention:

(*a*) **Diphtheritic Conjunctivitis.**—This disease consists of a deposition of diphtheritic exudation within the conjunctival layers, causing a board-like painful swelling of the lids and usually rapid ulceration of the cornea. It generally arises during an attack of diphtheria, and is commonest between the ages of two and eight, but is rare in infants.

The *treatment* should consist of cold applications, antiseptic irrigation of the conjunctiva, and atropine drops. French physicians advise the local application of lemon juice and citric acid ointment. Nitrate of silver should not be employed. Recent experiences indicate that diphtheria antitoxine is

the most serviceable remedy. The ordinary constitutional treatment of diphtheria is advisable.

(*b*) **Spring Conjunctivitis** (*Frühjahrskatarrh*).—This form of conjunctival inflammation is becoming more common in this country than was formerly the case. The symptoms are moderate mucous secretion and the formation of flat granulations in the conjunctiva, associated with hypertrophy of the tissue surrounding the limbus of the cornea. A somewhat characteristic behavior of the disease is its tendency to relapse, or, rather, to return in the early spring, and to subside in cool weather. It is rare in advanced life, and most frequent between the ages of five and fourteen. It may accompany the disease called hay-fever.

In addition to the treatment of an ordinary conjunctivitis, the best application to the everted lids is boroglyceride or a solution of bichloride of mercury 1 to 500. In troublesome cases the flattened granulations may be destroyed by expression or electrolysis.

Pterygium.—This is a somewhat fan-shaped growth, consisting of hypertrophy of the conjunctiva and subconjunctival tissue, and generally situated at the inner side of the eyeball, extending from the caruncle to the edge of the cornea. Its earliest appearance is frequently in the form of a *pinguecula*, or yellowish elevation composed of connective tissue and elastic fibres.

Treatment.—Small pterygia may be destroyed with the electro-cautery, larger pterygia excised and the defect covered with a flap of conjunctiva. When they are of great size and fleshy in appearance, excision is impracticable, and the pterygium should be split from apex to base and transplanted above and below, the transplanted portions being tucked beneath the conjunctiva and held in position with sutures. There is a marked tendency for pterygia to return, especially if the vascular tissue which composes their bases is not thoroughly removed.

Tumors and Cysts of the Conjunctiva.—Translucent cysts, nævi, and dermoid tumors appear as congenital conjunctival growths. Lipoma, fibroma, osteoma, and papilloma may be found in this situation. Usually their excision is attended with little difficulty.

Epithelioma and sarcoma occur in the conjunctiva, and sometimes may be excised without sacrificing the eyeball. If they are extensive, especially if the cornea and deeper tissues are involved, the entire globe must be extirpated.

Ecchymosis of the conjunctiva, or an extravasation of blood beneath this membrane, may result from an injury or appear during a paroxysm of coughing. It sometimes is spontaneous. Recurring subconjunctival hemorrhages in elderly people are not infrequently indicative of vascular changes, which in their turn are associated with Bright's disease.

Chemosis of the conjunctiva, or a distention of its connective-tissue layer with serum, is a symptom in various inflammatory conditions of the eye. It may also be an indication of Bright's disease, and is the common result of orbital inflammation or acute inflammations of the deeper structures of the eye—for example, the choroid coat.

Emphysema of the conjunctiva, or a distention of its connective-tissue spaces with air, occurs under the same condition which causes this phenomenon in the eyelids.

DISEASES OF THE CORNEA.

Inflammatory affections of the cornea are generally described under the name *keratitis*, and consist of infiltration of the layers of the cornea without the formation of pus or ulcers (non-ulcerative keratitis), or infiltration and loss of substance with the development of an ulcer (ulcerative keratitis), or infiltration of purulent material within the layers of the cornea (corneal abscess, purulent keratitis).

Phlyctenular Kerato-Conjunctivitis (strumous ophthalmia of the older writers).—In this disease single or multiple vesicles form on the conjunctiva, and particularly at the corneo-scleral margin. These vesicles are the so-called *phlyctenules*, and consist of an elevation of the corneal epithelium by a round-celled exudate.

The symptoms are local congestion, great lachrymation, and photophobia, the latter often being so marked a symptom that the lids are spasmodically closed and the head is buried in the bedclothes. After a time the phlyctenule breaks down, and an open lesion, or *phlyctenular ulcer*, results, which remains at the margin of the cornea, or creeps across its surface, followed by a leash of blood-vessels. Occasionally phlyctenules form a circle around the margin of the cornea (marginal keratitis), or a single pustule of yellowish color develops at the corneo-scleral junction, having a strong tendency to perforate this membrane.

The disease is common in childhood, especially in strumous subjects. It often follows the exanthemata, and is always associated with, and probably in many instances caused by, various pathological conditions of the rhinopharynx, particularly adenoid vegetations. Eczema of the nares, of the auricle, and of the face often accompanies this disease, which has a strong tendency to relapse, and may become one of the most troublesome of ocular affections.

Treatment.—This must be constitutional and local. Atropine drops should be used as long as there is irritation, and the conjunctival cul-de-sac should be frequently irrigated with a tepid boric acid solution. Later, an ointment of yellow oxide of mercury, one grain to the drachm, may be rubbed into the conjunctival sac. If the ulcer assumes a severe type, the treatment for sloughing ulcers, presently to be described, is applicable. The nasopharynx should be carefully treated according to the conditions which are found. The constitutional remedies are iron, arsenic, cod-liver oil, and the hypophosphites. Fresh air, a residence in the country, suitable diet, and all hygienic measures are important.

Ulcers of the Cornea.—In addition to ulcers due to phlyctenular keratitis, a number of varieties occur which have received different names, according to their situation, character, and tendencies. The most important are :

Simple ulcer, which is a small gray infiltration of the cornea, near its centre, and without much associated inflammation.

Indolent ulcer, which usually is a shallow lesion, although sometimes it may be excavated or gouged out, having a slightly turbid base, and which is especially chronic in its course. It probably depends upon some failure

in the nutrition of the cornea. It is frequent in anæmic and scrofulous subjects, and sometimes is caused by chronic inflammatory diseases of the conjunctiva.

Purulent or Sloughing Ulcers.—These ulcers, as their name indicates, represent a purulent infiltration of the cornea with ulceration. They are frequently associated with pus in the anterior chamber (*hypopyon*) and inflammation of the iris (*iritis*). The most characteristic type is the so-called *serpiginous* or *creeping ulcer*, which consists of a sharply marked lesion, the edges of which are deeply infiltrated and its floor gray and sloughing. It is likely to spread and perforate the cornea, causing iritis, irido-cyclitis, and even destruction of sight. Ulcers of this character usually start in an abrasion of the corneal surface, for example, after an injury. According to Uhthoff, they are caused by the pneumococcus of Fraenkel. The infection may come from purulent inflammation of the lachrymal passages. Instead of being an open lesion, the purulent infiltration is sometimes covered with an unbroken layer of epithelium, which bulges forward, and there results the condition which is known as *abscess of the cornea*. This depends upon an inoculation of the infected area with the pathogenic organisms of suppuration, and may occur under the same circumstances as those which originate purulent keratitis, or may appear in connection with constitutional disturbances, particularly small-pox, scarlet fever, and measles.

Other serious types of ulcers are those known as the *rodent ulcer*, or *circular ulcer*, which particularly selects the margin of the cornea, and rapidly eats its way through this membrane.

Dendriform ulcers, so named from their fancied resemblance to the skeleton veins in a lanceolate leaf, probably depend upon a special micro-organism, but are also, under some circumstances, caused by malaria and other constitutional disturbances. In addition to the symptoms of ulceration of the cornea, there is often marked neuralgia of the supra-orbital nerve.

Treatment.—The ordinary ulcers of the cornea, which have been described as simple ulcers, require the same treatment that is useful in phlyctenular keratitis. In place of the yellow oxide of mercury before mentioned, calomel may be dusted into the eye, but must not be used if the patient is taking iodide of potassium. Deep and sloughing ulcers require more vigorous measures. If there is any tendency to iritis, the pupils should be dilated with atropine, and this mydriasis maintained. Pain is alleviated and the process of repair encouraged by the application of hot compresses according to the method already described, and the conjunctival cul-de-sac and lachrymo-nasal duct must be frequently irrigated with a saturated solution of boric acid or formalin 1 to 2000.

The following measures are employed to stop impending perforation, and may be tried in the order named. *First*, a compress bandage applied over a dry, sterilized dressing; *second*, paracentesis of the cornea; *third*, curetting the ulcer, and dusting upon it finely powdered iodoform, to be followed by a pressure bandage; preceding the application of the iodoform, the edges of the ulcer may be pencilled with a sublimate solution 1 to 2000; *fourth*, destruction of the diseased area with nitrate of silver (gr. x to f℥i), applied by means of a camel's-hair brush; or with carbolic acid or tincture of iodine

applied on the end of a probe; or, finally, with the actual cautery, either in the form of a galvano-cautery, or, when this is not at hand, with a platinum probe heated red-hot in the flame of a Bunsen burner. The exact area to be destroyed may be outlined by dropping upon it a two per cent. solution of fluorescine, which colors greenish yellow all portions of the cornea denuded of epithelium.

If there is much hypopyon, this should be evacuated by means of a paracentesis corneæ, or, if the infiltration of the corneal layers exists without ulceration, the abscess may be opened with a delicate cataract-knife.

It is important in severe corneal ulceration to treat all associated conditions—namely, disease of the naso-pharynx, disease of the lachrymal passages, and disease of the teeth. Careful search should be made for foreign bodies and misplaced cilia. The constitutional treatment should consist of tonics, particularly iron, quinine, and arsenic, or of such remedies as may be indicated by any existing dyscrasia. Proper hygiene and diet, fresh air, and all measures which will promote the general health are of paramount importance.

Results of Corneal Ulceration.—The result of a corneal ulcer depends upon its depth and extent, but it should be remembered that every corneal ulcer leaves some form of scar. It may be slight, and is then called a *nebula* or *macula*, or dense and white, and is then known as a *leucoma*. If the ulcer has perforated, the iris is usually attached to the margin of the ulcer, and there is formed the so-called *anterior synechia*, which may begin to bulge and

Fig. 708.

Adherent leucomas of the cornea.

Fig. 709.

Staphyloma of the cornea.

produce a *partial corneal staphyloma* (Fig. 708), or, if the perforation has been an extensive one, there may be staphylomatous bulging of the entire corneal surface. (Fig. 709.)

Slight opacity of the cornea may be relieved by massage of the cornea with yellow oxide of mercury. Galvanism also has some repute. Well-marked scars, and particularly dense leucomas, are unaffected by this treatment. Vision may sometimes be helped by a suitably placed iridectomy, or the patient's appearance may be improved by tattooing the scar with India-ink. In staphyloma, iridectomy may prevent further bulging, or may be needed to alleviate pain or secondary glaucomatous symptoms, but if the staphyloma is unsightly and the eye blind, either enucleation or evisceration should be performed.

Neuroparalytic keratitis, or that variety of ulceration of the cornea which arises when this membrane has become isolated from the influence of the trigeminus, and which depends partly upon a dystrophic change and partly upon the lessened power of the insensitive cornea to resist external injuries, is particularly interesting to surgeons, since removal of the Gasserian ganglion has become a common operative procedure.

Treatment.—This should consist of exclusion of the eye from external irritants. It may be accomplished by stitching the lids together, or, better still, by placing over the eye a Buller's shield, precisely as this is used in connection with gonorrhœal cases. (Fig. 705.) In several cases treated by the author with Dr. W. W. Keen, not only has ulceration disappeared under this treatment, but it has been prevented, and he would recommend in all cases of removal of the Gasserian ganglion that at the expiration of the operation the eye upon the affected side should be immediately covered with a watch-crystal, carefully held in place with strips of plaster or gauze and collodion. The shield should not be removed for at least a week after the operation.

Interstitial Keratitis (Syphilitic or Parenchymatous Keratitis).—This disease is a diffuse keratitis, characterized by an infiltration of the true layers of the cornea, which gradually passes, without ulceration, but associated with superficial or deep vascularization ("the salmon patch of Hutchinson"), into a condition of opacity somewhat resembling ground glass.

Fully sixty per cent. of the cases depend upon inherited syphilis; in a few instances the disease follows acquired syphilis. Other cases arise under the influence of rheumatism, struma, rickets, and probably malaria and depressed nutrition. The disease is not common in adults, being most frequent between the ages of five and fifteen. Usually both eyes are affected, although the interval between the two attacks may vary from a few weeks to several months. It is said to have been delayed five or six years.

The disease lasts for many months, and, indeed, it is improbable that perfect clearing of the cornea ever occurs, although under proper treatment apparently hopeless cases may regain good vision. Years afterwards inspection of the cornea will reveal the minute channels once occupied by the new-formed blood-vessels. The disease may be associated with iritis, retinitis, and choroiditis, and sometimes gives rise to secondary glaucoma. Its subjects often manifest other signs of inherited syphilis, particularly periosteal nodes, fissures at the angles of the mouth and around the nares, and not infrequently deformed central incisors, which have vertically notched edges—the so-called Hutchinson's teeth.

Treatment.—This consists in the local application of atropine to avert iritis, and the constitutional treatment of syphilis, particularly inunctions of mercury. Every measure to improve the general health should be employed, and iron, arsenic, and cod-liver oil are constantly indicated. All irritant applications are contra-indicated. Goggles should be worn to protect the eyes from too strong light. If symptoms of glaucoma arise, iridectomy may be necessary, or, at least, paracentesis of the cornea. Severe pain may be allayed by hot applications, and, if the child is sufficiently robust, leeching the temple is a useful procedure.

Conical Cornea.—This is a cone-shaped bulging forward of the cornea, sometimes congenital, but usually developing about the fifteenth year. It is generally seen in women, and especially in those whose nutrition has been depressed by an exhausting illness. Even if the cone is transparent, vision is much disturbed, owing to the change in refraction, eyes of this character often being myopic and always highly astigmatic. In slight forms improvement follows the local use of eserine and the adjustment of suitable glasses. In advanced cases operation may be needed, either an optical iridectomy, or, better, the application of a fine galvano-cautery needle to the apex of the cone, which causes a contracting cicatrix and flattening of the protruding cornea. Later, an iridectomy may be required to improve vision.

OPERATIONS UPON THE CORNEA.

Paracentesis of the Cornea.—The cornea is punctured near its lower margin with a paracentesis-needle, which is inserted at an angle of forty-five degrees with the point of contact. The act of withdrawing the needle must be slowly performed, lest a sudden gush of aqueous cause prolapse of the eyeball. During the act of withdrawal the needle is slightly rotated on its

Fig. 710.

Paracentesis-needle with stilet.

long axis, which opens the lips of the wound and permits the contents of the aqueous chamber to escape. If necessary, the wound may be reopened on the following day with the probe end of the instrument. (Fig. 710.)

Saemisch's Section.—This operation is performed to evacuate pus in the anterior chamber or to check the progress of a sloughing ulcer. The eyeball is steadied with fixation forceps, and a cataract-knife is entered on one side of the cornea with its cutting edge forward, carried across the anterior chamber to the other side of the ulcer, and the section made directly through the diseased area, evacuating the collection of pus in the layers of the cornea or in the anterior chamber.

Operations for Staphyloma.—In partial staphylomas the protruding portion may be transfixed through its base with a cataract-needle. Next an elliptical piece of the cicatricial tissue is excised, together with the needle which transfixes it, by making an incision at one side of the needle with a narrow knife and another from the other side converging towards the first. The subsequent treatment consists in the application of a firm pressure bandage. A total corneal staphyloma may be abscised, but generally the best operation is evisceration. (See page 824.)

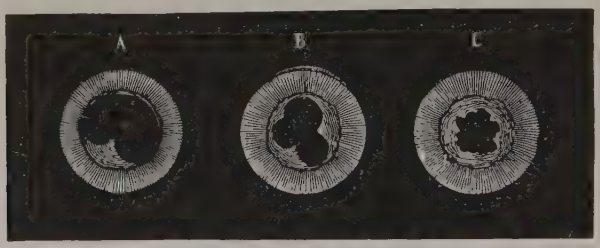
Tattooing the Cornea.—Some India-ink being rubbed into a fine paste, and the cornea being properly anæsthetized with cocaine, a sufficient quantity of pigment is spread over the white scar and pricked into place by needles specially made for this purpose. If the scar is not large, one sitting is sufficient; generally, however, it is better to repeat the tattooing on several occasions until a uniform black surface is obtained. The cosmetic effect of this operation is often very good.

DISEASES OF THE IRIS AND CILIARY BODY. SYMPATHETIC IRRITATION AND SYMPATHETIC INFLAMMATION.

Inflammatory affections of the iris are described under the name *iritis*, and are usually symptomatic of disorders in other portions of the eye or of disease of the general constitution, or they may be traumatic.

Symptoms.—These are: change in the color of the iris; pericorneal injection, usually known as "ciliary congestion;" contraction and irregularity of the pupil due to the formation of inflammatory attachments between the iris and capsule of the lens, the so-called *posterior synechiæ* (Fig. 711); irregularities on the surface of the iris due to accumulations of exu-

Fig. 711.



Posterior synechiæ. (Sichel.)

date; haziness of the cornea and turbidity of the aqueous humor. The subjective symptoms are pain, disturbance of vision, tenderness of the globe, photophobia, and lachrymation.

The *diagnosis* of iritis is most important, and the acute variety should be distinguished from acute conjunctivitis and acute glaucoma. In conjunctivitis the pupil is freely mobile, the vision is usually unimpaired, and there are no synechiæ; in glaucoma the pupil is dilated and fixed, without the presence of synechiæ, and the tension of the eyeball is raised.

Fig. 712.

Exclusion and occlusion of pupil following gummatous iritis. From a patient in the Philadelphia Hospital.

Iritis, when properly treated, presents a favorable prognosis. When improperly treated, or when allowed to run its course without treatment, the iris is bound throughout the whole extent of its pupillary edge (*exclusion of the pupil*), or there is a deposition of inflammatory material within the pupil (*occlusion of the pupil*). During iritis there may be associated inflammation of the cornea, the ciliary body, or the deeper structures of the eye. (Fig. 712.)

Treatment.—The treatment of iritis must meet several indications. First, prompt dilatation of the pupil by means of atropine, four grains to the ounce, or other suitable mydriatic, and maintenance of this mydriasis during the entire course of the disease. Second, recognition of the constitu-

tional disease which has caused the iritis, and exhibition of suitable remedies to counteract its influence. Third, suppression of pain, which is very severe, by the use of hot compresses, bloodletting from the temple, especially with Swedish leeches, and the internal administration of analgesics.

It is customary to divide iritis, which may be acute, subacute, or chronic, into three chief varieties, plastic, parenchymatous, and serous, these names indicating the pathological characters of the inflammation.

Simple plastic iritis may be due to syphilis, rheumatism, which are the two most frequent causes, gonorrhœa, gout, and diabetes and other constitutional complaints. It may also follow injury, and sometimes appears when neither local nor constitutional disease seems to be present.

Syphilis is the cause of plastic iritis in from thirty to sixty per cent. of the cases. It generally appears from the second to the ninth month after the initial lesion, but may be delayed until the eighteenth month. It does not differ in appearance from non-syphilitic types of iritis, and therefore cannot be said to be diagnostic of the disease which has caused it.

Its **treatment** should consist of the measures already described under the general treatment of iritis, together with those suited to the stage of syphilis in which it occurs. Of these measures the best, in the judgment of the author, are inunctions of mercury, followed by iodide of potassium. In some instances cure is hastened by the subconjunctival injection of bichloride of mercury (two drops of a 1 to 2000 solution), or by a similar injection of a physiological salt solution.

Rheumatic iritis should be treated locally precisely as any other form of plastic iritis, and constitutionally with remedies which will counteract the rheumatic or gouty diathesis. It is more apt to relapse than other forms of iritis, and is probably more painful than most types.

Gonorrhœal iritis usually does not coincide with nor follow the gonorrhœal attack. Almost always an arthritis of the knee, sometimes of the ankle, supervenes. In addition to the ordinary treatment of iritis, both local and constitutional, profuse sweats with pilocarpine are efficient.

Parenchymatous iritis may be caused by syphilis, infectious diseases, particularly recurrent fever, pneumonia, typhus, typhoid fever, and septicæmia, and may follow traumatism.

Syphilitic parenchymatous iritis, or, as it is frequently called, *gummatous iritis,* appears in the late secondary stages of syphilis, and is characterized, in addition to the ordinary symptoms of iritis, by the appearance of one or more yellowish or reddish-yellow nodules, varying in size from a hemp-seed to a small pea, situated in the tissue of the iris. True gumma of the iris, which occurs as a solitary yellowish growth, almost constantly at the ciliary border, and usually involving the ciliary body, appears at a period in which gummata are common in other portions of the body.

The **treatment** is the same as that for any other type of syphilitic iritis, although the author has usually found that massive doses of iodide of potassium answer a better therapeutic purpose than mercury. The treatment of traumatic iritis does not differ from that of the other varieties, except that iced compresses should be employed.

Serous iritis may be caused by syphilis, rheumatism, menstrual disorders, and anæmia so far as this is representative of blood dyscrasia.

The usual treatment is required, except that atropine must be cautiously employed, because there is a tendency to rise of tension and secondary glaucoma. Under these circumstances either paracentesis of the cornea or iridectomy may be required.

Tumors and Cysts of the Iris.—Delicate transparent cysts occasionally form in the iris, and others having solid contents, which take their origin in a cilium which has passed into the anterior chamber, the so-called "implantation cyst," may arise. Several varieties of small solid tumors may develop in this tissue:

(*a*) Grayish-red nodules, especially at the margin of the pupil, miliary growths, in fact, which on examination prove to be tubercles containing bacilli and giant-cells. (*b*) Sarcoma of the iris, which usually appears between the twentieth and fortieth years. It commonly arises in the lower portion of the iris, and is generally pigmented. (*c*) Granulomata of the iris, which are small growths, and in some instances appear to be the forerunners of sarcoma and in others are closely analogous to tubercle of the iris.

A cyst or small sarcoma of the iris may be removed, together with the involved iris-tissue, by means of a broad iridectomy. If, however, the deeper structures are involved and the disease has begun to spread, enucleation is indicated.

OPERATIONS UPON THE IRIS.

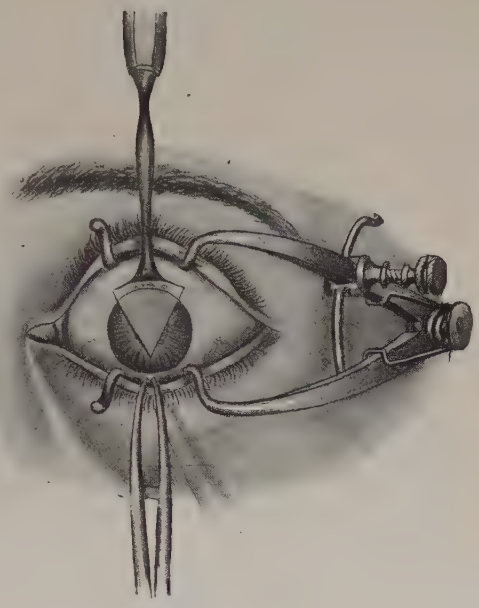
Iridectomy.—In all operations upon the eye the following preparation of the patient should be made. The closed lids, eyebrows, and surrounding facial area should be sterilized in the ordinary way with soap and water, followed by a bichloride douche. The conjunctival cul-de-sac should be cleansed by flushing it with a tepid solution of boric acid. The use of strong germicides is contra-indicated. For an hour preceding the operation the eye should be covered with a preparatory bandage, which consists of a pad soaked in a solution of bichloride of mercury 1 to 5000, held in place with a few turns of a sterile gauze roller. All instruments should first be placed in boiling water, from that transferred to absolute alcohol, and finally covered with sterile water. Solutions of atropine, cocaine, and similar drugs, before being dropped into an eye, should be sterilized by boiling, as they are very prone to accept contamination of all kinds.

The following instruments are required for an iridectomy: a stop speculum, fixation forceps, bent keratome, iris forceps, iris hook, iris scissors, and small spatula. In place of the bent keratome a Graefe cataract-knife may be used.

Operation.—The eye being cocainized, the surgeon stands behind his patient, and if using the bent keratome, the point of the knife is brought in contact with the apparent corneo-scleral margin, or, in some instances, about a millimetre from the junction of the sclera with the cornea, and in a direction at right angles to the cornea, which direction it keeps until the point just penetrates the anterior chamber. The handle is then well depressed, so that the point of the knife shall not wound the iris or the lens,

while the blade is slowly thrust onward until the section is of the desired extent. (Fig. 713.) The knife is then slowly withdrawn, its point being kept well forward towards the posterior surface of the cornea. The iris forceps are now introduced through the lips of the wound, the pupillary margin of the iris is seized, and a portion of the iris is withdrawn, which is then cut off with one or two snips of the iris scissors close to the margin of the wound. (Fig. 714.)

Fig. 713.



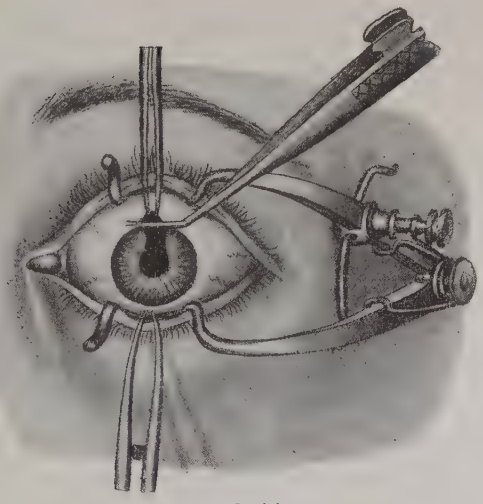
Insertion of bent keratome in performing iridectomy.

An iridectomy may be broad and peripheral, or narrow, or occasionally quite small, with preservation of the ciliary border. The most common indications for iridectomy are—

(1) For optical purposes—that is, to replace an occluded or an excluded pupil—a narrow iridectomy should be performed. (Fig. 715.)

(2) To relieve tension and open the periphery of the anterior chamber—as, for example, in the treatment of glaucoma—a broad peripheral iridectomy should be performed. (Fig. 716.)

Fig. 714.

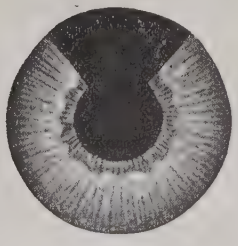


Cutting the iris.

Fig. 715.

Narrow iridectomy.

Fig. 716.



Broad peripheral iridectomy.

(3) To prevent recurring attacks of inflammation in the iris, and sometimes to aid in the healing of a corneal ulcer—a medium-sized peripheral iridectomy should be performed.

(4) To remove a portion of the iris containing a foreign body or growth —an iridectomy sufficiently large to accomplish this purpose is required.

(5) Preliminary to the extraction of cataract, or for the purpose of ripening cataract—a medium-sized iridectomy is usually required.

DISEASES OF THE CILIARY BODY. SYMPATHETIC IRRITATION AND SYMPATHETIC INFLAMMATION.

Cyclitis.—Inflammatory affections of the ciliary body are described under the name cyclitis, and are usually seen in association with iritis: hence the term *irido-cyclitis.*

Symptoms.—They are not unlike those already described in connection with iritis, but are more decided—namely, œdema of the upper lid, great tenderness on pressure, precipitates in the cornea, extensive posterior synechiæ, and marked lessening of visual acuity, due to opacities in the vitreous. The tension of the eye is generally either lowered or raised. The injection of the circumcorneal or ciliary zone is always marked. Like iritis, cyclitis may appear in a plastic, a serous, or a purulent variety.

The prognosis is always grave, and the disease may terminate in glaucoma or atrophy of the iris and the choroid, while in the purulent varieties the vitreous becomes filled with opacities, the lens becomes cataractous, and the eyeball shrinks—the so-called *phthisis bulbi.*

The causes of cyclitis are similar to those of iritis. As already stated, the two are usually combined, and the treatment of the disease is the same as that already described in connection with iritis.

Inasmuch as injuries of the ciliary body are prone to be followed by the so-called sympathetic affections of the eyes, it is convenient to consider them in this connection.

Sympathetic irritation and **sympathetic inflammation** are two distinct affections, although usually spoken of in close connection, inasmuch as they originate from the same conditions. Sympathetic affections of the eye are most commonly caused by punctured wounds of the ciliary region, which set up a traumatic irido-cyclitis. They may also be due to foreign bodies, wounds and ulcers of the cornea, operations on the eye, dislocation of the lens, and ossification and calcification of the choroid and ciliary body.

Sympathetic irritation is a functional disturbance, and generally shows itself in the form of photophobia, lachrymation, blepharospasm, and pain through the ciliary region and supra-orbital nerve area. It may arise within a few days after the reception of an injury, and sometimes occurs as early as forty-eight hours. The injured or diseased eye which causes the sympathetic irritation is called the "exciting eye," and the eye which is implicated as the result of the disease or injury, the "sympathizing eye."

The **treatment** of sympathetic irritation consists in the removal of the exciting eye, or, at least, in treatment which prevents impulses from passing from this eye to the other.

Sympathetic inflammation, or ophthalmitis, is a serious organic disease, to which the general name *uveitis* is applicable, because its lesions are found in the uveal tract—that is, the iris, the ciliary body, and the choroid. It may appear as an irido-cyclitis, a serous iritis, or an inflammation involving the choroid and retina, its earliest manifestation sometimes being an inflammation of the optic papilla.

The period of incubation of this disease is from three to six weeks. It is said to have occurred as early as the seventh day.

No satisfactory explanation of sympathetic ophthalmitis has been given, although no doubt the theory of infection best explains it, and probably there is a transference of micro-organisms from the injured eye to its fellow.

The prognosis is exceedingly bad, and if sympathetic ophthalmitis has once begun, it always leaves most serious results.

Treatment.—The most important treatment is prophylaxis; that is to say, an eye so diseased or injured that it is likely to produce sympathetic ophthalmitis should be removed, or so treated that it will be harmless. It is difficult to formulate exact rules in regard to enucleation or evisceration under these circumstances. In general terms it may be stated that if an eye is so injured that it is sightless and the ciliary region is affected, and especially if a foreign body has entered the eye and judicious efforts have failed to extract it, enucleation or one of its substitutes should be performed. Even if the injured eye is not sightless, the ciliary region being involved in a septic inflammation, the eyeball should be subjected to similar treatment.

If sympathetic inflammation has already begun, the rules just quoted do not apply, and enucleation must not be performed if there is any vision in the exciting eye, which in the end may prove to be the more useful organ. If, however, the exciting eye is blind, and sympathetic inflammation has already begun, it should be enucleated in the hope of removing a source of irritation and thus rendering the treatment of the second eye more effectual.

The medicinal treatment of sympathetic inflammation is similar to that of iritis.

Panophthalmitis.—This term is applied to a general inflammation of all the tissues of the globe, and may be caused by injury, septic operations upon the eyeball, or sloughing ulcers of the cornea, and is seen also in pyæmia, septicæmia, endocarditis, cerebro-spinal meningitis, small-pox, and a number of other diseases.

The symptoms are œdema of the lid, chemosis of the conjunctiva, and purulent inflammation of the ciliary body, the choroid, and the vitreous. The inflammation usually spreads to the orbital tissues, which become exceedingly swollen and cause excessive protrusion of the globe. After a time the globe ruptures and shrinks, and we have the condition known as *phthisis bulbi.*

Treatment.—This may consist of bloodletting from the temple, frequently changed iced compresses, and the internal administration of opium and quinine; but as sight is usually destroyed early in the disease, and the pain is very severe, evisceration of the eyeball should be performed, or, if this is not possible, deep incisions should be made very much as one would treat an abscess to relieve tension.

Enucleation.—Enucleation of the eyeball is performed as follows. A stop-speculum being introduced and the patient being fully etherized, the surgeon divides the conjunctiva in a circle close to the margin of the cornea. The tendons of the ocular muscles, beginning with the superior rectus, are then successively raised upon a strabismus hook and divided. The eye being made to start forward by inserting the stop speculum somewhat more deeply, the globe is drawn forward and a pair of curved scissors, introduced between the severed conjunctiva and the freed eyeball, is made to follow the curve of the latter until the optic nerve is reached, when the blades are expanded, and the nerve included between them and severed. The attachments of the oblique muscles and the remaining tissue which may cling to the eyeball are then divided. The conjunctival wound may be closed with silk sutures, iodoform dusted in the socket, and an ordinary compress bandage applied. It is rarely necessary to pack the orbit, as hemorrhage can readily be controlled by pressure.

Evisceration.—Instead of enucleation, evisceration may be practised, which consists in an evacuation of the contents of the eye within the sclerotic and the closure of the sclero-conjunctival wound with sutures. Evisceration with the introduction of a glass ball into the scleral cavity, *Mules's operation*, is much practised by some surgeons. The operation is performed precisely like an evisceration, except that before the sutures are introduced a hollow glass ball is inserted into the scleral cup and the sclera stitched over it, precisely as the leather cover of a ball is stitched over its contents. A successful operation results in an excellent, movable stump, upon which the artificial eye may rest.

GLAUCOMA.

Glaucoma is a disease of the eye manifested in its typical varieties by increased tension of the eyeball, dilatation of the pupil, shallowness of the anterior chamber, greatly impaired vision, anæsthesia of the cornea, and intense pain. Ophthalmoscopically, there is usually an excavation of the optic disk, the so-called glaucoma cup. Glaucoma may be either primary or secondary, and its two chief varieties are acute and chronic glaucoma.

Acute Glaucoma.—In the prodromal stage of acute glaucoma there may be failure in the power of accommodation, temporary obscuration of vision, and colored halos around artificial lights. The "glaucoma attack" itself, which often appears in the night, is characterized by intense pain, swelling of the lids, steaminess of the cornea, semi-dilated and motionless pupil, greatly increased tension of the eyeball, and rapid loss of vision.

This disease has frequently been mistaken for iritis, and the error in diagnosis has been the cause of the loss of the eye. The distinguishing characteristics have already been pointed out (page 818).

Chronic Glaucoma.—Often there are no signs in the anterior aspect of the eye, save, perhaps, slight steaminess of the cornea and a little lack of transparency in the aqueous humor. The diagnosis must be made with the ophthalmoscope, which reveals a cupped disk, a halo around the edge of the papilla, and sometimes pulsation of the retinal vessels, especially the

arteries, while the field of vision is markedly contracted, usually upon the nasal side.

Glaucoma is rare before the fortieth year, and is said to be slightly more common in women than in men. Certain races, particularly the Jews, are especially liable to the disease. It is more common in hypermetropic eyes than in those with normal or myopic refraction, and is excited in eyes predisposed to the disease by insomnia, bronchitis, arterial sclerosis, and gout. It sometimes follows the instillation of atropine, and this drug and all other mydriatics are always contra-indicated in the treatment of this disease, or of eyes predisposed to it.

Treatment.—The medicinal treatment of acute glaucoma consists in the instillation of a solution of sulphate of eserine, one-half or one grain to the ounce. Pain may be relieved by hot compresses, leeches, and the exhibition of morphine and chloral. At the earliest moment, however, a broad peripheral iridectomy should be performed. (See Fig. 716.)

In chronic or so-called simple glaucoma the value of iridectomy is much more problematical. If the progress of the disease fails to yield to eserine or hydrochlorate of pilocarpine (one-eighth or one-quarter of a grain to the ounce), and if the iris is not atrophied, iridectomy or, in some instances, sclerotomy ought to be performed. Much judgment is required to determine the value of operative procedures in this type of the disease.

In addition to these varieties of glaucoma there are others, which are known as

Subacute inflammatory glaucoma, in which the symptoms are analogous to the chronic types, with more tendency to inflammatory involvement.

Glaucoma fulminans, in which all the inflammatory symptoms are greatly magnified, and blindness comes on with great suddenness.

Secondary glaucoma, in which the increased tension and the glaucoma symptoms are seen in connection with other diseases of the eye, particularly iritis and cyclitis.

Hemorrhagic glaucoma, in which, in addition to the glaucoma symptoms, there are hemorrhages in the retina.

The *treatment* of these varieties must be conducted on the principles applicable to the ordinary types, save only that in hemorrhagic glaucoma iridectomy is usually a dangerous procedure and is apt to be followed by increased hemorrhage. Some good may be obtained by posterior sclerotomy, or by tapping the vitreous, in addition to the local medicinal treatment already described.

CATARACT.

Cataract, or an opaque condition of the crystalline lens, anatomically is divided into *lenticular*, *capsular*, and *capsulo-lenticular* cataract. Clinically, the following varieties are distinguished : *senile*, *juvenile* or *congenital*, *complicated* or *secondary*, *traumatic*, and *after-cataract*.

Senile cataract usually forms after the fifteenth year of life, and is hard—*i.e.*, the nucleus of the lens is large. The opacities begin in the cortex (*cortical cataract*) or at the nucleus (*nuclear cataract*). The growth from incipiency to maturity may occupy from one to three years, or longer.

The **symptoms** of incipient cataract are depreciation of vision in proportion to the extent of the opacities, change in the refraction of the eye, which often becomes temporarily myopic from swelling of the lens (the so-called "second sight"), and sometimes monocular diplopia. With the ophthalmoscope the streaks and spots may be seen in the lens. Mature cataract can usually be detected without special examination, or, at most, with oblique illumination.

A cataract is ripe when the opaque lens covered with its capsule is level with the margin of the iris, and when the iris casts no shadow during illumination of the pupillary space. The color of senile cataract varies ; it may be amber, white, or black. If it is over-ripe the cortex liquefies (Morgagnian cataract).

Treatment.—Incipient cataract requires no special treatment, except that the patient should be given such glasses as may improve his vision. Electricity and massage of the eyeball are of no avail.

Juvenile or Congenital Cataract.—Complete juvenile or congenital cataract is usually white or bluish-white in color, and is soft—*i.e.*, the nucleus is small. The eye may be otherwise healthy, or there may be associated change in the choroid, the retina, and the optic nerve. Complete white cataract also forms in young persons without known cause.

Of the partial congenital cataracts, the two most important are the *zonular* or *lamellar* cataracts and the *pyramidal* cataracts. The latter are small opacities situated either in the anterior (anterior capsular or polar) or the posterior (posterior polar) portion of the lens or its capsule.

Complicated or secondary cataracts may form on account of various diseases of the eye, complete lenticular opacity being common after severe irido-cyclitis, choroiditis, glaucoma, etc. Partial secondary cataract at the anterior pole of the lens may follow a perforating ulcer of the cornea, or may develop at the posterior pole in connection with high myopia, choroiditis, and vitreous disease. Complete cataract may be caused by diabetes, and is often associated with albuminuria.

Traumatic cataract has been described on page 798.

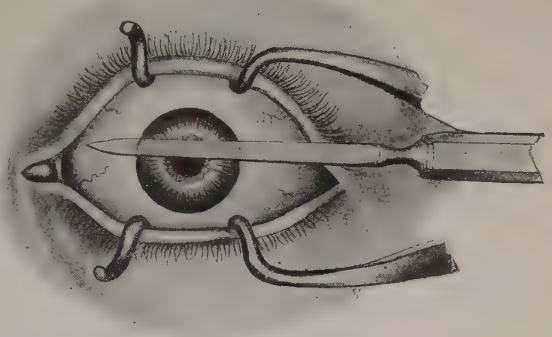
After-cataract, usually called *secondary cataract*, is the name applied to the thickening and opacity of the capsule of the lens which frequently occurs after the extraction of cataract.

Operations for Senile Cataract.—Hard cataracts, or those which occur after the fortieth year, may be removed by one of several methods. Two will be described: (*a*) combined extraction, or extraction with iridectomy, and (*b*) simple extraction, or extraction without iridectomy.

(*a*) **Combined Extraction by the Short or Three-Millimetre Flap Operation.**—The following instruments are required: a stop speculum, a lid elevator, fixation forceps, spatula, wire loop, small spoon, cystotome, capsule forceps, iris forceps, iris scissors, and the cataract-knife. The eye and patient having been properly prepared (see page 820), and the speculum being inserted, the surgeon seizes a fold of conjunctiva with the fixation forceps at the inferior border of the cornea and draws the eyeball gently downward. The knife is next entered exactly at the corneo-scleral junction, at the outer extremity of a horizontal line which would pass three milli-

metres below the summit of the cornea, carried across the anterior chamber to a point directly opposite the point of entrance, and counter-puncture effected. The incision is completed with a slightly sweeping movement, the edge of the knife being kept well upon the border of the cornea. (Fig. 717.)

Fig. 717.

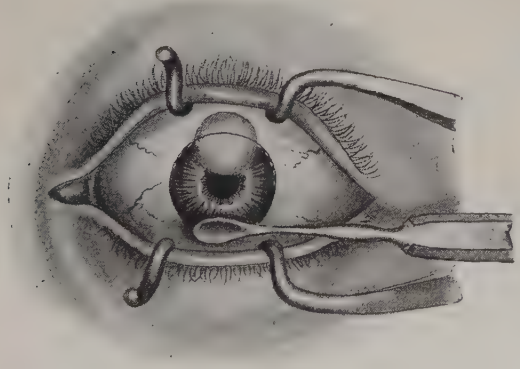


Cataract extraction. Puncture and counter-puncture have been made.

The iris forceps are now inserted between the lips of the wound, and a small piece of iris is excised in the manner already described. (See page 821.) Next the cystotome is introduced and passed to the bottom of the coloboma. Its cutting edge being turned towards the lens capsule, a T-shaped opening is made.*

The lens is delivered by making pressure, with an upward movement, against the inferior portion of the cornea with the back of a polished spoon. (Fig. 718.) Finally, the toilet of the wound is performed, during which cortical remnants and tags of capsule are expelled from the coloboma, the edges of the iris are carefully replaced, and the wound margins are brought into exact coaptation.

Fig. 718.



Expulsion of lens.

(*b*) **Simple Extraction, or Extraction without Iridectomy.**—This operation is performed in its main features exactly as the one just described, save only that the iridectomy is omitted, and that the section for full-sized cataracts should comprise exactly the upper half of the cornea; for smaller, Morgagnian and soft cataracts, somewhat less.

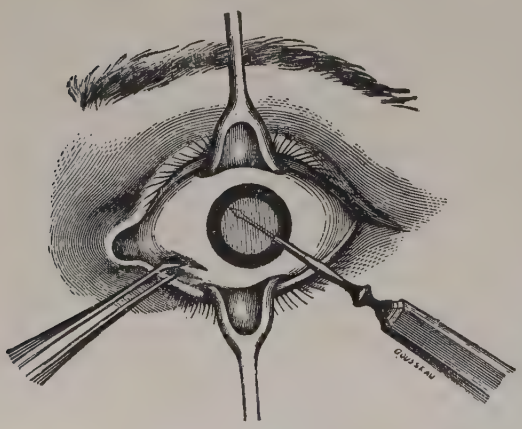
After extraction by either method, the eyes may be dressed with small oval pads of sterilized gauze and cotton, held in position with a few strips of surgeon's isinglass plaster. Over this dressing a shield or mask may be placed, among the best being the one known as Ring's ocular mask. The dressings should be removed daily and the outside of the lids bathed with tepid bichloride solution (1 to 5000), but if there has been no pain and there

* There is much difference of opinion as to the exact method of opening the capsule, many surgeons preferring to open it in its periphery.

is no sign of irritation in the lids or increased secretion on the pads, the eyes need not be opened until the third or fourth day, when the lids may be cautiously parted and a drop of atropine solution instilled. On the fifth day the bandage may be removed from the eye not operated upon, and by the end of a week the patient may usually dispense with the dressing entirely and wear dark glasses and a shade. If there are no contra-indications, the patient should remain in bed for four or five days. After simple extraction, it is advisable to inspect the eye at each dressing, to be sure there has been no prolapse of the iris. A cataract glass may be ordered about six weeks after a successful extraction.

Operation for Juvenile and Congenital Cataracts.—A soft cataract is usually dealt with by the operation for solution, or *discission*. It is performed as follows: the lids being separated by a stop-speculum, the surgeon fixes the eye with forceps and introduces a cataract-needle through the cornea at its outer side and carries it across to the centre of the pupil, where the point is turned towards the lens, the shaft is caused to enter the cornea a little more deeply, and a laceration is made in the capsule by depressing the handle of the instrument with a lever-like movement. (Fig. 719.) The operation usually has to be repeated at intervals. The first incision should be a slight one, lest rapid extrusion of the soft lens-matter into the anterior chamber should produce injurious pressure on the iris and the ciliary body. At the second incision the laceration may be greater—in fact, two needles may be used.

Fig. 719.



Discission, or needling.

The after-treatment of discission consists in the use of atropine and a light pressure bandage. If there is much reaction, iced compresses are advisable, and should iritis supervene the usual treatment is indicated.

If the lens-matter gives rise to glaucomatous symptoms on account of the pressure before described, it should be evacuated by a *linear extraction*—that is, by the introduction of a keratome about one millimetre within the margin of the cornea, until it has made a wound five millimetres wide. Through this wound the soft lens-matter will escape if counter-pressure is made on the cornea with a spud while the outer lip of the corneal wound is depressed with a curette. Sometimes the lens-matter is removed by the *suction method*, the point of a properly constructed syringe being introduced behind the lens-matter to be removed, which is then sucked up in the barrel in the ordinary way.

Operation for After-Cataract or Secondary Cataract.—A Knapp's knife-needle is introduced at the temporal side of the cornea, three milli-

metres from its margin, and its point made to transfix the capsule at the inner margin of the dilated pupil. The capsule is first cut horizontally, then the needle is passed in front of the lower segment of the capsule, which it transfixes near the lower margin of the pupil, and which is divided by an upward incision. Next the needle is passed in front of the upper segment of the capsule, which is divided by a downward incision. Besides the danger of iritis and cyclitis in operations of this character, a certain number of cases develop secondary glaucoma. In this event a small peripheral iridectomy should be performed.

DISEASES OF THE LACHRYMAL APPARATUS.

Dacryoadenitis.—Inflammation of the lachrymal gland is a comparatively rare affection, causing pain, tenderness, and swelling at the upper and outer part of the eyelid, with chemosis of the conjunctiva. If suppuration occurs, the pus should be evacuated, by an incision made either through the integument or through the conjunctiva.

Tumors of the lachrymal gland produce swelling in the same situation. They may be solid—for example, adenoma, osteoma, and sarcoma—and

Fig. 720.

Enlarged lachrymal gland of the right eyelid in a man aged fifty-five years. (After Snell.)

Fig. 721.

Adenoma of the lachrymal gland in a woman of twenty-five years. (After Snell.)

sometimes cystic. Excision of the growth, together with the gland, is the proper treatment. (Figs. 720, 721.)

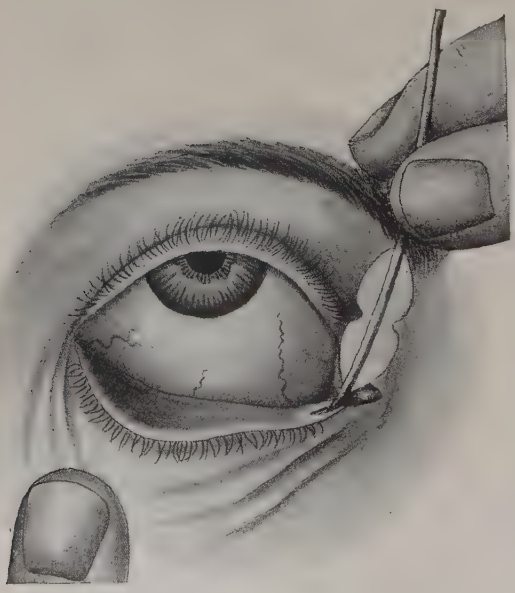
Dacryocystitis, or an inflammation of the lachrymal sac, usually produces a slight swelling over the region of this structure (*mucocele*, or *lachrymal tumor*), and when pressure is made upon this the contents of the inflamed sac will be expressed through the puncta—either semi-transparent mucus (*catarrhal dacryocystitis*) or pus (*purulent dacryocystitis*). Occasionally the surrounding tissues are involved in the inflammation (*phlegmonous dacryocystitis*). Whenever pus or muco-pus is found in the lachrymal sac the surgeon may be reasonably sure that there is stricture of the nasal duct—an obstruction which usually antedates the sac-inflammation.

The most common causes of disease of the lachrymal sac and nasal duct are morbid conditions in the nasal chambers and naso-pharynx, inflamma-

tion of the lachrymo-nasal mucous membrane after the exanthemata, periostitis and caries of the lachrymal bone, pressure from neighboring tumors —for example, in the antrum of Highmore—foreign bodies, and traumatism.

Treatment.—If the disease is not an aggravated one, an attempt may be made to check the inflammation by antiseptic irrigation through the point of a fine syringe introduced through the punctum without slitting the canaliculus: in fact, it is advisable always, if possible, to avoid injuring this structure. In most instances of organic stricture, however, it is necessary to slit the canaliculus with a suitable knife, the probe-point of which is introduced into the punctum, while the lid is drawn down and out with the thumb. The knife is pushed on until it touches the inner wall of the lachrymal sac, when it is raised to the vertical line with the cutting blade turned slightly inward. A lachrymal probe may now be introduced, in order to find the position of the stricture, and passed through it. Bowman's and Williams's probes are the most suitable. The probe is introduced by passing it horizontally along the canaliculus until its point touches the lachrymal bone. It is then raised to the vertical position and pushed into the duct, remembering that the direction should be downward, slightly backward, and outward. (Fig. 722.) If judicious efforts fail to introduce the probe, the stricture may be divided by a suitable knife, introduced in the same manner as is the probe. One of the most useful instruments is the stricturotome of Charles Hermon Thomas, of Philadelphia. When sounds are employed they should be used at first every second or third day; after a time longer intervals may elapse.

Fig. 722.



Introduction of the lachrymal probe.

During this treatment the lachrymo-nasal duct should be frequently irrigated with an antiseptic fluid—for example, bichloride of mercury 1 to 5000, formalin 1 to 2000, or a weak solution of nitrate of silver 1 to 1000. The treatment of any case of obstructive lachrymo-nasal disease is incomplete unless at the same time thorough attention is paid to the naso-pharynx. Under certain circumstances, especially in children, and in cases where it is necessary to divide the stricture, an excellent plan is to introduce a style made of lead wire, slightly hooked over the inner canthus to prevent its slipping into the nose.

DISEASES OF THE ORBIT.

Injuries of the orbit have already been described on page 802. In addition we have to consider periostitis, caries, necrosis, and cellulitis of the orbit.

Orbital periostitis and caries are practically identical with these affections when they occur elsewhere in the body, and need no special consideration here.

Cellulitis.—This is an inflammation of the cellulo-fatty tissue of the orbit, and in its acute variety is characterized by chills, deep-seated pain, intense headache, prominence of the eyeball, and limitation of its movement, with swelling and œdema of the lid. Later there may be optic neuritis, anæsthesia of the cornea, ulceration of this membrane, and even suppuration of the eyeball. The affection may be caused by exposure to cold, is especially common after certain fevers—scarlet fever, typhoid fever—and the most violent types are seen with facial erysipelas. Others occur from extension of inflammation in the ethmoid cells or the frontal sinus, and, finally, certain cases are metastatic, occurring in connection with pyæmia.

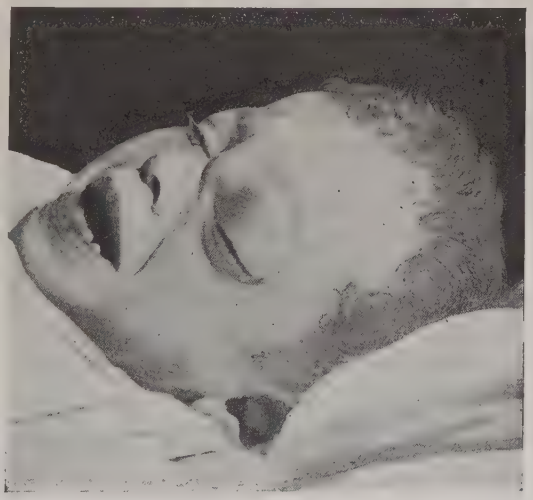
Treatment.—Locally frequently changed hot compresses are suitable, but as early as possible the pus should be evacuated, the incision being made with a knife introduced flatwise at the point of greatest fluctuation.

Tumors of the Orbit.—Independently of those which occur in connection with the eye itself, morbid growths may arise from the bony walls of the orbit—namely, exostoses, osteomas, and those which originate in the tissues of the orbit, which include cysts—sebaceous, dermoid, and serous—and a variety of tumors—angiomas, lipomas, lymphomas, and chondromas, together with the various types of sarcoma.

In addition to the actual prominence which gives indication of the growth, hard, soft, or fluctuating, according to the character of the tissue, the usual symptoms are exophthalmos, partial or complete immobility of the eyeball, diplopia, chemosis of the conjunctiva, and œdema of the lid.

If possible, an attempt should be made to remove growths of this character without injuring the eyeball. If the tumor is malignant, however, in most instances it is necessary to remove the entire contents of the orbit. (Fig. 723.)

Fig. 723.



Sarcoma of orbit. (Case under care of Dr. Wharton in the Children's Hospital.)

Pulsating Exophthalmos.—This name is applied to a variety of conditions in which the most prominent symptoms are exophthalmos, pulsation, and a bruit which is heard not only over the eyeball itself, but over the entire skull-cap. In addition, there may be intense venous hyperæmia of the posterior conjunctival vessels, enlargement of the cutaneous veins, retinitis, retinal hemorrhages, and optic neuritis.

At one time such phenomena were supposed to be due to aneurism of the orbit, but it has been demonstrated that proptosis, pulsation, and bruit may be caused by extra-orbital aneurism of the ophthalmic artery, aneurism of the internal carotid, and aneurismal varix, involving the internal carotid and the cavernous sinus. The last-named lesion—namely, arterio-venous communication—is the one most frequently responsible for these phenomena. Not far from two hundred cases are on record, and traumatism is responsible for at least sixty per cent. of them. Ordinarily the exophthalmos is unilateral, appearing on the same side as the lesion, but bilateral vascular protrusion has been noted in a number of instances, for example, in one reported by the author. Somewhat similar symptoms are caused by pulsating angioma and sarcoma of the orbit.

True vascular protrusion caused by arterio-venous communication between the internal carotid and the cavernous sinus is best treated by ligation of the common carotid. If this is declined, compression, with or without the administration of iodide of potassium, may be tried.

Strabismus, or Squint.—Only very brief mention of this important topic is possible. Strabismus includes those conditions in which the visual axis of one eye is directed away from the point of fixation. It may be *convergent*, *divergent*, *upward*, or *downward*. Furthermore, the squint may be *concomitant*—that is, the squinting eye is able to follow the movements of the other eye in all directions—or *paralytic*—that is, there is limitation of movement in the direction of the action of the affected muscle.

Concomitant Convergent Strabismus.—This is the ordinary "crossed eye," and may be *permanent* or *periodic*, *monolateral* or *alternating*. In general terms, concomitant squint is due to a disturbance of the relation which exists between the power of accommodation of the eyes and their power of convergence, caused by errors of refraction; in convergent squint, usually by hypermetropia; in divergent squint, generally by myopia. Many other causes and theories have been advanced to explain squint. For their full consideration the student must refer to ophthalmic works. Quite commonly the squinting eye is amblyopic, and this amblyopia has been regarded as the cause of the squint.

Concomitant squint must be distinguished from *paralytic* strabismus, which may be caused by syphilis, rheumatism, diphtheria, poisons, and diseases of the brain, especially at its base. In a paralytic strabismus there is limitation of the movement of the affected eye in the direction of the paralyzed muscle, and commonly double vision. By a study of the double images the surgeon is enabled to diagnosticate the affected muscle.

The **treatment** of concomitant convergent strabismus includes, first, thorough mydriasis with atropine, during which the refractive error should be carefully measured and suitable glasses provided. If these fail to

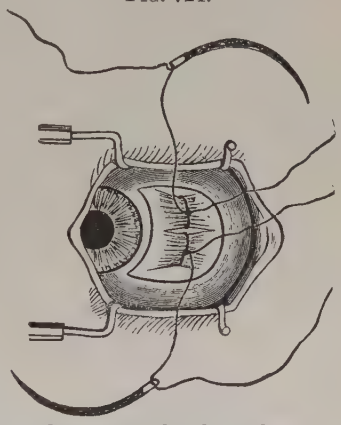
straighten the eye, tenotomy or advancement, or both operations, may be required.

Tenotomy of an Ocular Muscle.—This is performed as follows. The eye being thoroughly cocainized (general anæsthesia is inadvisable), the tendon of the muscle to be divided (in convergent strabismus the internal rectus) is exposed by a small horizontal incision directly over its insertion. This incision divides first the conjunctiva, then the capsule of Tenon. A strabismus hook is now introduced beneath the exposed tendon and drawn well forward to its insertion, and the tendon separated from its attachment to the sclera by a few snips with a blunt-pointed scissors. If the effect of the tenotomy is to be increased, the capsule of Tenon is divided on each side, as well as the fibres which pass from the caruncle to the internal rectus. The conjunctival wound is then closed with a stitch placed vertically. Concomitant divergent squint is remedied by tenotomy of the externus, with or without advancement of the internus.

In place of tenotomy, or associated with it, we have the operation of advancement or readjustment.

Advancement of an Ocular Tendon.—The insertion of the tendon is exposed, and the strip of conjunctiva between the opening and the cornea detached from the sclera. A hook is then inserted beneath the tendon and brought well up to its insertion. A suture armed with a needle at each end is next inserted in the upper border of the margin of the tendon between it and the sclera, and passed through the tendon at its middle line. Similarly another suture is passed behind the tendon from its lower margin close to the first. Each of these is firmly knotted on the tendon. The tendon is now separated with scissors, and the sutures are passed through the conjunctival flap and the episcleral tissue, and are tied with their own ends. (Fig. 724.) Numerous methods have been devised for advancing ocular muscles, the one briefly described being that which the writer has commonly employed. There is perhaps no other operation in ophthalmic surgery which requires so much judgment as that directed to the relief of strabismus, and before it is undertaken the surgeon should thoroughly understand the subject.

Fig. 724.



Advancement of ocular tendon. (Swanzy.)

CHAPTER XXIX.

INJURIES AND DISEASES OF THE EAR.

Congenital Defects of the Ear.—These may involve the auricle, the external auditory meatus, the middle ear, or the internal ear.

Congenital defects of the auricle may be unilateral or bilateral, and result from imperfect development of the visceral arches, consisting in *supernumerary* auricles or imperfect development of the auricle, associated with imperfect development of the auditory meatus, the bony canal, and the tympanic ring. These defects are often associated with impaired hearing. The auditory canal may be entirely absent, and in such cases the deformed auricle is apt to be very movable, and is not situated in its normal position, being nearer the cheek or the neck.

Congenital fistula of the ear, which arises from arrested closure of the first visceral cleft, is a deformity which is occasionally seen. It consists of a deep fossa or a small fistulous opening, which may be symmetrical, and occupies a position in front of the tragus or the helix, or in the concha; the fistula often extends parallel to the meatus, but leads towards the pharynx, and occasionally discharges a watery fluid or pus.

Treatment.—Supernumerary auricles may exist without marked impairment of hearing, and the removal of these appendages may be undertaken for cosmetic reasons. Imperfect development of the auricle, if not accompanied by loss of hearing, requires no special treatment, but if associated with diminished hearing power and partial occlusion of the meatus, a plastic operation to enlarge the meatus and expose the auditory canal may be undertaken, with occasional good results. In cases where no meatus exists and the malformed auricle is displaced, the auditory canal and the tympanic cavity are in all probability absent, and no operative treatment can be beneficial. Congenital fistula, if not accompanied by pain and purulent discharge, needs no treatment, but if the opposite conditions are present, cauterization or antiseptic injections may be followed by permanent closure of the sinus.

INJURIES AND DISEASES OF THE AURICLE.

Wounds of the Auricle.—These may be incised or lacerated, or may result from bites of animals; a not infrequent injury of this appendage occurs from an ear-ring being forcibly pulled from the ear, causing a cleft of the lobule. **Treatment.**—In wounds of the auricle the separated parts should be accurately approximated by the use of sutures, care being taken to bring together injured portions of the cartilage, so that the shape of the ear shall be preserved as far as possible. An antiseptic dressing is applied, and, on account of the great vascularity of the part, prompt healing usually

takes place. Clefts of the lobule if seen early should be approximated with sutures, but if healing has occurred before the case comes under the care of the surgeon, leaving a fissure in the lobule, the edges of the cleft should be freshened and approximated by sutures.

Frost-Bite of the Auricle.—Frost-bites of varying degrees of severity are common accidents in cold climates, and in severe cases, if sudden reaction takes place, gangrene of the auricle is apt to occur. The *treatment* is similar to that for severe frost-bites in other parts of the body. The greatest caution should be observed to bring about reaction gradually. After reaction in these cases and in the case of superficial frost-bites, the use of an ointment of ichthyol, twenty-five per cent., and petrolatum, seventy-five per cent., is followed by the best results.

Fig. 725.

Fibroma of the auricle.

Burns and scalds of the auricle are also often seen, and their treatment is similar to that employed in the same conditions in other parts of the body.

Tumors of the Auricle.—The auricle may be the seat of various tumors, such as cysts, nævus, epithelioma, fibroma, sarcoma, and lipoma. Keloid and fibroma following wounds of the auricle or piercing of the lobe for the application of ear-rings are not uncommon, and are very often seen in negroes. (Fig. 725.) The treatment of tumors of the auricle consists in excision of the growth, the cartilage being preserved as far as possible if it is not diseased, and, if a large gap is left, skin-grafting or a plastic operation may be employed.

Othæmatoma, or Hæmatoma of the Auricle.—This consists of a cyst containing serum or blood, which results from injury to the auricle (Fig. 726), is often observed in boxers or foot-ball players, and is also common in insane patients; the term "asylum ear" is sometimes applied to this affection. Its presence in the insane is commonly ascribed to minor injuries to the auricle, which in their depressed vascular condition cause the extravasation, or to central lesions, the restiform bodies being the portion of the brain said to be involved. The **treatment** of hæmatoma of the auricle consists in the use of pressure and massage, or of mild counter-irritants, and aspiration may be practised with good results in some cases. It is wiser not to incise the swelling unless suppuration occurs, in which case the sac should be incised and irrigated with an antiseptic solution, and gentle pressure made by an antiseptic dressing. Under either method of treatment more or less deformity is apt to result.

Fig. 726.

Hæmatoma of the auricle.

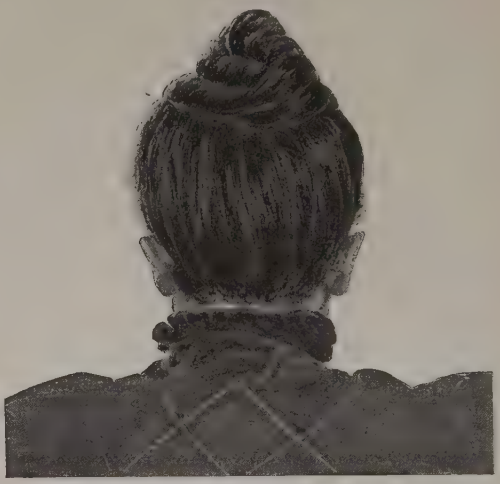
Prominent Auricles.—Undue prominence of the ears constitutes a marked deformity. The condition may result from the shape of the carti-

lages or from their irregular development. In addition to prominence of the ears there may be associated a dropping forward of the upper portions, which causes the ears to present the appearance which is normal in the ears of fox-terriers. (Fig. 727.) The latter deformity seems to be due to irregular

Fig. 727.

Prominent and drooping ears.

Fig. 728.



Result of operation for prominent ears, in the case shown in Fig. 727.

development of the cartilage, which is abnormally thick at some parts and very thin at its upper part.

Treatment.—Prominent auricles in infants can often be corrected by wearing continuously a band or cap holding the ears against the head; in children or adults the deformity can be satisfactorily corrected by a plastic operation. The operation consists in first removing an elliptical section of skin from the back of the ear; when the cartilage has been exposed, an elliptical section of the cartilage, about one-quarter of the size of the section removed from the skin, is excised, care being taken that the skin upon the anterior surface of the cartilage is not perforated. The edges of the wound in the cartilage are next approximated by two or three catgut sutures, and the edges of the skin incision are also brought together by sutures. We usually employ a suture of fine chromicized catgut. After the sutures have been tied, the ear is brought close to the head, and an antiseptic dressing is applied and held in place by a bandage. The dressing need not be disturbed for a week or ten days, at which time the wound is generally firmly healed, and if silk sutures have been used they should be removed. The patient should, however, wear at night a cap or a bandage to keep the ears close to the head and prevent stretching of the scar. The result of an operation for prominent auricles is seen in Fig. 728.

Acute and *chronic inflammation* of the auricles may arise from injuries, or may show itself in the form of erysipelas, herpes, or acute or chronic eczema. The treatment of these conditions is similar to that for like conditions in other parts of the body, and need not be detailed here.

INJURIES AND DISEASES OF THE EXTERNAL AUDITORY MEATUS.

Wounds of the Meatus.—These may result from foreign bodies forced into the ear, or from blows or falls rupturing the skin lining the canal. Free hemorrhage usually results from such wounds. The meatus should be carefully irrigated with a warm antiseptic solution or with sterilized water to remove the blood, the surface of the wound covered with powdered boric acid or iodoform, and a plug of antiseptic cotton worn in the external meatus for a few days.

Follicular Abscess, or Furuncle of the Meatus.—This is a very common and painful affection of the ear, which results from the infection of the hair-follicles by septic matter, usually introduced in cleaning the ear with a stick or a pencil. When infection occurs, itching is first noticed, soon followed by severe pain and marked swelling of the soft parts in the auditory canal. If the furuncle is situated deeply in the canal, it may be difficult to expose it to view even by the use of a speculum.

Treatment.—This consists in syringing the canal with hot water or mopping it with peroxide of hydrogen, and the use of a cotton tampon saturated with a ten per cent. solution of ichthyol; as soon as pointing has occurred the furuncle should be incised, antiseptic irrigation employed, and ichthyol subsequently applied, pressure being made with a cotton tampon.

Diffused Inflammation, or Cellulitis of the External Meatus.—This is a not uncommon affection; it may result from infection, causes marked swelling of the soft parts of the meatus, and may be accompanied by a purulent discharge; if the discharge contains mucus as well as pus, it is an evidence that the tympanic and accessory cavities are also inflamed.

The symptoms of diffused inflammation of the external auditory meatus are rapid swelling of the soft parts, narrowing of the canal, and intense pain. **Treatment.**—This consists in the use of injections of warm antiseptic solutions; if the pain is not soon relieved a few deep incisions should be made through the swollen tissues, and warm antiseptic irrigation subsequently employed.

Tumors of the Auditory Meatus.—**Sebaceous Cysts.**—These are occasionally seen occupying the outer portion of the canal, and are similar to those observed upon the scalp and other parts of the body. As they increase in size they close the canal and produce tinnitus and deafness, and, if not removed by operation or spontaneous rupture, may result in necrosis or caries of the surrounding bone from the pressure which they cause. The **treatment** consists in incising the wall of the tumor and turning out its contents, and, if possible, dissecting out the sac; if this is not practicable, the inner surface of the sac should be cauterized or curetted and loosely packed with gauze.

Epithelioma of the External Auditory Meatus.—This growth may develop in the auditory canal, or the canal may be involved by extension of a growth from without. When the growth originates in the canal, pain is a very prominent symptom. After exposing the canal with a speculum the growth can be seen; a portion may be removed by forceps or a curette

and examined microscopically to confirm the diagnosis. The **treatment** consists in removing the growth as far as possible by the use of a curette.

Exostoses of the Auditory Canal.—Bony growths of the auditory canal occasionally occur, and are said to be most common in swimmers, whose ears are frequently exposed to cold water. The growths increase slowly in size, but may attain such dimensions that they obstruct the canal and produce deafness. The **treatment** consists in incising the skin over the tumor and dissecting it free from the growth; this may then be removed by dividing its base with a fine chisel, or it may be cut away by a burr or trephine attached to a dental engine.

Polypi of the Auditory Canal.—These tumors may be composed of granulation-tissue, or may be of the fibro-cellular variety, and usually grow from the mucous membrane of the tympanum, but may also arise from the deeper portions of the auditory canal, springing from the inflamed and macerated cutis in connection with cases of chronic otorrhœa, or from granulations about the opening of a furuncle the healing of which has been delayed. Their presence is accompanied by muco-purulent discharge and blood; pain may or may not be a prominent symptom.

Treatment.—The seat of the polypi being exposed by a speculum, the growths may be removed by a snare, or twisted off by fine angular aural polypus forceps, and after they have been removed their bases may be touched with chromic acid, great care being taken to use only enough acid to cover the base of the tumor. The subsequent treatment consists in keeping the canal clean by the use of irrigation with antiseptic solutions, or by cleansing it with cotton applied by an applicator, and the insufflation of a powder of boric acid and aristol or of iodoform.

Impacted Cerumen.—This usually results from injudicious attempts to remove the cerumen by a swab, by which means the wax is pushed inward and forms a considerable mass, which gradually increases in size until the auditory canal is filled with the secretion. The symptoms of impacted cerumen are singing or buzzing in the ear and more or less impairment of hearing, coming on suddenly. These symptoms should lead to an examination of the ear with a speculum, when a brown mass can be seen filling the auditory canal.

Treatment.—Impacted cerumen is best removed by syringing with warm water, 105° to 110° F.; this will usually be followed by the escape of the mass of wax in fragments, unless the mass is very dry, in which case it may be softened by introducing into the ear a solution of carbonate of sodium, gr. xx; glycerin, f℥i; water, f℥i; a few drops of this solution should be dropped into the ear at intervals of an hour or so before the syringe is used, and after this treatment the mass can usually be promptly removed by syringing with warm water.

Foreign Bodies in the Auditory Canal.—These may consist of animate or inanimate objects. The *animate* objects which find their way into the canal are flies, ants, bugs, or moths, or the larvæ of flies may be deposited here, giving rise to maggots. The movements of these objects when they gain access to the ear often cause severe pain: they can be quickly killed by dropping a little sweet oil into the ear, or by allowing

the fumes of chloroform or ether to enter the auditory canal, and their subsequent removal may be accomplished by syringing the ear with warm water, or by using a speculum and forceps.

A great variety of *inanimate* objects are found in the auditory canal, such as pebbles, beans, peas, small buttons, and grains of wheat or corn. These objects are generally introduced into their own ears by children in play. They usually produce little discomfort at first, and it is only after they have been in the canal for some time and set up inflammation that their presence is recognized. Dry objects, such as peas, beans, or grains of corn, which absorb moisture and increase in size, may produce pain by pressure, and such objects are often quite difficult to remove.

Treatment.—The safest method of removing foreign bodies from the ear is by syringing the canal with warm water, which usually will be followed by the removal of the body. In cases, however, in which the body has become swollen and impacted, it may be necessary to use a wire loop, forceps, or a scoop to dislodge and remove it. Great damage has often been done to the ear by unskilful attempts to remove a foreign body by forceps or a scoop, so that syringing should always first be employed, and these instruments should be used only under general anæsthesia where syringing has been unsuccessful.

INJURIES AND DISEASES OF THE MEMBRANA TYMPANI.

Injuries of the Membrana Tympani.—Rupture of this membrane may result from blows upon the ear, or from the explosion of powder or gases, or the membrane may be perforated by sharp objects introduced into the auditory canal, such as nails, pins, pencils, or sticks. When rupture of the membrane occurs, there are experienced a ringing sound and pain, and often nausea and dizziness, with more or less impairment of hearing.

Treatment.—In traumatic rupture or perforation of the tympanic membrane no attempt should be made to inject fluids into the ear to cleanse the wound, as they are apt to set up inflammation of the middle ear; but the auditory canal should be closed with a plug of antiseptic cotton, and this should be allowed to remain in place for a few days. These wounds usually heal promptly, satisfactory repair often occurring in one or two days.

Myringitis.—Inflammation of the membrana tympani may exist as an acute or a chronic affection. Acute myringitis may be excited by the entrance of irritants into the ear, by cold air or cold water, or by the growth of aspergillus upon the membrana tympani. The membrane becomes reddened and swollen, and sharp pain may be experienced. When the myringitis is due to the presence of aspergillus the membrane is covered with a grayish layer of tissue, which may extend to the walls of the auditory canal, and resembles in appearance wet paper; there are also itching and pain and a scanty watery discharge. The diagnosis of aspergillus can be confirmed only by microscopic examination of the false membrane.

Treatment.—In cases of myringitis due to cold water or cold air, dry heat should be applied to the ear, and its use is often followed by relief of the pain; if not relieved by this treatment, scarification of the membrane should be practised. If there is discharge from the ear, the auditory canal

should be syringed with a 1 to 60 carbolic solution, and powdered boric acid insufflated. In case of myringitis due to aspergillus the cavity should be illuminated by a head-mirror, and the membrane carefully detached by the use of delicate forceps, or by syringing the ear with a solution of peroxide of hydrogen or alcohol 1 part, warm water 3 parts, the surface then being dusted with a powder composed of salicylic acid 1 part, boric acid 16 parts.

DISEASES OF THE MIDDLE EAR.

Inflammation of the Middle Ear.—This is one of the most common aural diseases, and may exist as a catarrhal or as a purulent affection.

Otitis Media Catarrhalis.—This consists in a catarrhal inflammation of the mucous membrane of the middle ear, and usually results from cold in the head. It is very common in children, but is also seen in adults, and is characterized by intense pain or earache. From sepsis this variety of inflammation of the middle ear may pass into the purulent form, constituting the affection known as *otitis media purulenta*. This latter affection is often observed as a sequel of the exanthemata in children.

Treatment.—This consists in the application of dry heat to the ear, which is accomplished by the use of a hot-water bag or bottle or a Japanese hand-warmer, or by the injection of water into the auditory canal as hot as the patient can bear. If this does not relieve the pain, an anodyne may be required. If the pain is not relieved by this treatment, it is probable that the catarrhal otitis will soon pass into the purulent form, and to avoid suppuration leeches should be applied, two Swedish leeches being placed in front of the tragus and one beneath the lobule of the ear. If in spite of these measures the pain continues, the patient should be etherized and the tympanum perforated with a paracentesis knife or needle, the point of the perforation being indicated by the bulging of the membrane. The after-treatment consists in the use of hot douches, if antiseptic gauze tampons do not suffice to remove the secretion as fast as it is formed.

Chronic Catarrh of the Middle Ear.—This affection results from repeated attacks of acute catarrh of the naso-pharynx or middle ear, and is accompanied by a chronic hypertrophic condition of the mucous membrane of the tympanic cavity and its contents, with retraction of the membrana tympani and partial ankylosis of the ossicles. The symptoms of chronic catarrh of the middle ear are tinnitus and more or less impairment of hearing; pain is usually slight.

Treatment.—As this affection depends largely upon disease of the naso-pharyngeal membrane, the treatment of that condition is a prime factor in the cure of the disease, and consists in the use of medicated sprays and local applications, as well as the removal of the hypertrophied tissues, where accessible, by the use of the galvano-cautery. The catarrhal swelling of the mucous membrane prevents the entrance of air into the tympanic cavity, and the inflation of the Eustachian tube and the cavity of the tympanum should be accomplished by the use of Politzer's method or the Eustachian catheter. The method of inflation known as Politzer's is that most easily practised, and consists in throwing air into both tympanic cavities at the moment of swallowing by a rubber bag, the nozzle of which is placed in

one nostril while the other nostril is closed. The patient takes a mouthful of water and at a word from the surgeon swallows it, when the latter compresses the gum bag, forcing the air into the Eustachian tubes. This inflation should be repeated two or three times a week. Various methods of auto-inflation, such as blowing with the mouth and nose closed, are also practised, but are not, as a rule, to be recommended unless done under the direction of the surgeon. Pneumatic massage with the Siegle speculum or with the finger-tip is often very useful in improving hearing and lessening tinnitus.

Chronic Otorrhœa, or Otitis Media Purulenta Chronica.—This is a very common and dangerous affection, in which a muco-purulent discharge escapes from the ear or ears through a perforation in the membrana tympani; the ossicles, the bony walls of the tympanic cavity, and the mastoid cells may become necrosed, and polypi are generally present, growing from the walls of the tympanic cavity or the membrana tympani. The affection often occurs in children as a sequel of scarlet fever or measles. A patient suffering from chronic purulent otitis may develop cerebral abscess, phlebitis, thrombosis of the lateral or petrosal sinuses, or general pyæmia. So fully is the danger of this condition recognized that no life-insurance company will accept as a risk a person who presents a running ear.

Symptoms.—The most marked symptoms of chronic purulent otitis are a chronic muco-purulent and offensive discharge, and pain at times if the discharge is retained, with more or less impairment of hearing.

Treatment.—The treatment of this affection consists, first, in keeping the cavity of the ear clean by the daily use of injections of warm water or warm boric solution, or by carefully cleansing the ear with absorbent cotton on an applicator, and the subsequent injection of a solution of carbolic acid 1 to 40, or bichloride of mercury 1 to 2000. The ear after being carefully dried should be treated by insufflations of boric acid finely powdered, or of a powder of aristol and boric acid. This is especially useful if the perforation in the tympanic membrane is a large one. The occasional application of a ten- to thirty-grain solution of nitrate of silver by means of a cotton applicator is also of advantage. If granulations or polypi are present, these should be diminished under the above treatment, but if they are not they should be removed by a snare, or may be destroyed by the careful application of a little chromic acid applied by means of a probe. If it is found that the ossicles or the bony walls of the tympanic cavity are necrosed, excision of the ossicles is demanded, as well as the removal of the surrounding necrosed bone. These operations are extremely delicate, and for their description the reader is referred to special articles upon Aural Surgery. The sequelæ of chronic purulent otitis media, such as thrombosis of the petrosal or lateral sinuses, and cerebral or cerebellar abscess, are considered under Diseases of the Head, pages 717 and 718.

Mastoid Disease.—Periostitis of the external surface of the mastoid may result from acute or chronic inflammation of the external auditory canal or middle ear, especially deep furuncles, but inflammation of the mastoid cells, resulting in caries or necrosis of the bone, usually follows chronic or acute purulent inflammation of the middle ear, and may occur at

any age. The involvement of the mastoid usually develops suddenly after exposure to cold or the introduction of cold water into the ear. The development of inflammation of the mastoid is evidenced by the occurrence of throbbing and boring pain, and of tenderness upon deep pressure over the mastoid process. At the same time the discharge from the ear diminishes or ceases, and more or less marked febrile symptoms develop. Facial paralysis caused by the pressure of the swollen mucous membrane or of pus upon the facial nerve is not an uncommon symptom. The purulent collection resulting from inflammation of the mastoid cells may be confined for a time in these cells, but soon perforates the bony walls, and may enter the cranial cavity, giving rise to meningitis or a cerebral abscess, or there may develop sinus-thrombosis, or the collection may escape by perforating the external surface of the mastoid, or may find its exit by the digastric fossa, causing a swelling behind the ear or beneath the origin of the sterno-cleido-mastoid, limiting the movements of the lower jaw. If not relieved by rupture externally, the condition is a most serious and fatal one unless free drainage is effected by surgical aid. The swelling of the mastoid tissue, with an abscess under the periosteum, forces the auricle outward and forward, causing the appearance well shown in Fig. 729. *Chronic inflammation* of the mastoid may result in a sclerosis or thickening of the bone, with disappearance of the cells—a condition sometimes accompanied with much neuralgic pain, which can be relieved by chiselling an opening into the thickened bone.

Fig. 729.

Deformity from mastoid abscess.

Treatment.—As soon as it is evident that inflammation of the mastoid is present, a free incision should be made through the skin and periosteum, a quarter of an inch behind the auricle, extending the whole length of the mastoid process, and the auricle and skin should be drawn forward. If a sinus in the bone is exposed, this should be enlarged by cutting away its walls freely with a gouge, so as to expose the mastoid cells. If no sinus is present, the bone should be perforated with a small trephine or gouge at a point near the posterior and upper wall of the external auditory canal, and the wound should be carefully enlarged until the mastoid cells have been freely opened, care being taken to avoid injury of the lateral sinus, which is in close relation to the mastoid antrum at this point. In long and narrow skulls the sinus is not likely to be encountered (Körner), but in short, broad skulls and in children it lies more superficially. When the cells have been freely exposed, pus and necrosed tissue should be carefully removed with a curette. If the lateral sinus is injured, free venous bleeding occurs, which may be controlled by packing the wound with iodoform gauze. The cavity

should next be freely irrigated with an antiseptic solution, or dry mopping may be employed, and, finally, loosely packed with gauze. If no internal perforation has occurred, the symptoms of mastoid disease rapidly disappear after this operation, and the wound gradually heals by granulation, leaving a depressed scar. In a considerable group of cases there is extension to the inner surface of the bone, with pus-collection external to the dura, which is generally thickened and granular. Involvement of the adjacent cerebrum or cerebellum is apt to follow, going on to abscess-formation.

CHAPTER XXX.

SURGERY OF THE AIR-PASSAGES.

Wounds and Injuries of the Larynx and Trachea.—The larynx or trachea may suffer from *contusion* or *fracture* of the cartilages, with laceration of the mucous membrane, from blows, or from falls upon the neck. Incised and lacerated wounds of the larynx or trachea may result from sharp or blunt instruments applied to the neck, as in stab or cut-throat wounds, or from sharp or irregular foreign bodies which find their way into the larynx; gunshot wounds of the larynx or trachea are also occasionally observed. Cut-throat wounds are those most commonly met with, and in these the larynx, the trachea, or the crico-thyroid or thyro-hyoid membrane may be incised. The would-be suicide usually makes a transverse incision over the most prominent part of the larynx, and often opens the thyro-hyoid space and injures the epiglottis, and as soon as air escapes from the wound he desists, so that the great vessels of the neck seldom are injured; the superficial jugular veins are occasionally divided in the incision.

Symptoms.—In contusions and lacerations of the larynx or trachea the most prominent symptom is dyspnœa, which results from swelling and œdema of the mucous membrane, or from displacement of the lacerated cartilages; expectoration of blood and of frothy, blood-stained mucus may also be observed if the mucous membrane has been ruptured. In stab, lacerated, or cut-throat wounds involving the larynx or trachea, the escape of bloody, frothy mucus from the wound, dyspnœa, dysphagia, and retraction of the ends of the divided tube, if the division has been a complete one, are the most prominent symptoms. The symptoms following wounds of the larynx or trachea from foreign bodies are the expectoration of mucus and blood, and more or less dyspnœa. The immediate danger in all cases of injury or wound of these organs is swelling or œdema of the mucous membrane, which may produce death by suffocation unless relieved by operative treatment. Death from hemorrhage is comparatively rare, but may occur; but the escape of a moderate amount of blood into the lungs may later give rise to a septic pneumonia which may prove fatal.

Treatment.—Contusions and lacerations of the trachea and larynx, if there is no marked displacement of the fragments nor dyspnœa, should be treated by rest in bed and the application of an ice-bag to the neck over the injured organ, the patient being carefully watched. If the breathing is obstructed, an intubation-tube should be used, or the trachea opened and a tracheotomy-tube introduced. In incised, lacerated, or cut-throat wounds the hemorrhage should be controlled, and the edges of the incision in the walls of the larynx or trachea should be brought together with catgut sutures. If the epiglottis has been partly detached, it should be carefully approxi-

mated with sutures, and the superficial wound then closed with sutures. If dyspnœa occurs after the wound has been closed, the trachea should be opened below the wound and a tracheotomy-tube introduced. In cases of extensive incised and lacerated wounds, it is safer to perform tracheotomy and introduce a tube, plugging the trachea above the tube with iodoform gauze, to prevent the entrance of blood into the lungs, the packing also serving to retain the fragments in position. The tracheotomy-tube should be worn for a week or ten days, until the wound is healed, the patient being kept in bed with the head thrown forward, so as to relieve the wound from tension, and for a few days fed with a stomach-tube or by nutritious enemata, as swallowing is painful and tends to disturb the parts.

Fractures of the Larynx and Trachea.—Fractures of the cartilages of the larynx and trachea may occur at any age, although ossification of the cartilages does not take place until advanced life. Fractures of the cartilages of the larynx and trachea may be produced by blows, or by violent squeezing of the parts, or by hanging. **Symptoms.**—Pain, followed by rapid swelling and deformity of the neck, is a prominent symptom; bloody expectoration, emphysema of the neck, and alteration or loss of voice, are often present, and respiration and deglutition soon become difficult. Marked dyspnœa is a very common symptom of this injury. Every fracture of the larynx or trachea should be considered a most serious injury, for if dangerous symptoms do not immediately follow, inflammatory symptoms may supervene later, which will cause a fatal termination unless prompt treatment is resorted to. In twenty-seven cases of fracture of the larynx reported by Hunt, ten recovered and seventeen died. **Treatment.**—In cases of fracture of the larynx or trachea, where there is little displacement and dyspnœa is not marked, the parts should be supported by the application of a compress of lint held in place by adhesive straps, and the patient should be kept at rest in bed with the head and neck immobilized as far as possible. If, however, there is free expectoration of blood, and the respiration is embarrassed, tracheotomy should be promptly performed, and if the injury is seated in the larynx the displacement of the fragments may be overcome by manipulation with the finger or a director through the tracheal wound, or the larynx may be packed with strips of antiseptic gauze to control hemorrhage and hold the fragments in position, the patient in the mean time breathing through a tracheotomy-tube secured in the tracheal wound. The packing should be removed in a few days, the tracheotomy-tube being permanently removed as soon as the patient can breathe comfortably through the larynx with the tracheal wound closed. In fractures of the trachea, if possible, the opening into the trachea should be below the seat of injury.

Scalds or Burns of the Larynx.—These injuries arise from the inhalation of steam or flame, or may result from the action of caustic substances, such as lye or ammonia, which are swallowed and come in contact with the epiglottis or find their way into the larynx. Scalds of the larynx arising from the inhalation of steam are the most frequent of these injuries, and are commonly seen in children who have attempted to drink from the spout of a tea-kettle containing hot water. **Symptoms.**—Pain and grad-

ually increasing difficulty in respiration are the most marked symptoms. In all these cases the lips, tongue, cheeks, and pharynx will show evidence of the action of the irritant; in scalds, these parts are first white, and the mucous membrane soon becomes congested; a very similar appearance may be presented from the application of escharotics. Dyspnœa is due to œdema of the mucous membrane of the epiglottis and larynx, preventing the entrance of air, which, if not relieved, soon produces death by asphyxia. If death from asphyxia is averted, these cases may terminate fatally later from bronchitis, from pneumonia, or from stenosis resulting from cicatricial contraction. **Treatment.**—In cases where the scald or burn has not been severe and the dyspnœa is not marked, the patient should be placed in bed, cold compresses or an ice-bag being applied to the neck, and the patient should inhale the vapor from a steam spray. Under this treatment in mild cases recovery may take place. If, however, the difficulty in breathing is marked when the patient is first seen, or is gradually increasing in spite of the treatment which has been described, the sooner an operation is undertaken to relieve the dyspnœa the better will be the patient's chances of recovery. The operation indicated in these cases is tracheotomy or intubation of the larynx; the former we think the wiser procedure, for intubation is not likely to be of service if the epiglottis is involved, though it may be of service if the œdema is confined to the mucous membrane of the larynx. These operations relieve the dyspnœa, and are often followed by recovery; but a certain number of cases, even after the obstruction to breathing is removed, die of congestion of the lungs, bronchitis, or pneumonia.

Œdema of the Glottis.—This affection, characterized by the effusion of serum in the submucous connective tissue of the epiglottis, the larynx, or the vocal cords, rarely involving the larynx below the cords, may arise from various causes. Œdema of the glottis may develop rapidly after burns or scalds of the epiglottis or larynx, or may follow wounds of the base of the tongue, impaction of foreign bodies in the larynx, fracture of the hyoid bone or cartilages of the larynx, or caustic applications to the larynx. It may appear as a secondary complication of acute or chronic laryngitis, of acute tonsillitis, of syphilitic or tuberculous ulceration of the larynx, or of carcinoma of the larynx. Œdema may also arise in the course of chronic nephritis, measles, scarlet fever, erysipelas, or cellulitis of the neck.

Fig. 730.

Œdema of the glottis. (Agnew.)

Symptoms.—These may develop rapidly or slowly, and consist of pain and discomfort in the region of the larynx, suppression of the voice, a constant cough, unattended with expectoration, and stridor in breathing, especially in inspiration. Dyspnœa and dysphagia develop, and in extreme cases, as the dyspnœa becomes urgent, the face is cyanosed, the eyeballs protrude, and the patient presents a marked picture of mental and physical distress. If the conditions are not relieved by operation, the patient soon dies of suffocation. The diagnosis of œdema of the glottis may be made by inspection of the parts with a laryngoscope, or,

if this is not at hand, the introduction of the finger will often disclose the condition of the epiglottis, which will be felt as a soft elastic tumor the size of a horse-chestnut, its cartilaginous outline being entirely masked by the swollen tissues. (Fig. 730.)

Treatment.—If the symptoms are not extremely urgent, scarification of the epiglottis with a sharp-pointed knife may be employed; a curved bistoury, wrapped with adhesive plaster to within one-third of an inch of its point, is a satisfactory instrument for this purpose, the part being exposed by a laryngoscopic mirror, or, if this is not at hand, the incision being guided by the index finger placed upon the epiglottis. Scarification is followed by free escape of blood and serum, and usually rapid improvement in the symptoms. If, however, the dyspnœa is urgent, or recurs after scarification, tracheotomy or intubation should be performed. Tracheotomy is the operation which is likely to be followed by the best results, for if the epiglottis is œdematous, as is usually the case, the introduction of an intubation-tube is difficult, and when introduced the swollen epiglottis prevents the entrance of air. The immediate result of tracheotomy in these cases is usually satisfactory, the dyspnœa being relieved, and the swelling of the œdematous tissues rapidly subsiding; but many cases subsequently die, especially those in which the affection has developed as a sequel of nephritis, scarlet fever, or erysipelas.

LARYNGITIS.

This affection may exist as an acute or as a chronic catarrhal laryngitis, simple membranous laryngitis, diphtheritic laryngitis, acute œdematous laryngitis, or tuberculous or syphilitic laryngitis.

Acute Catarrhal Laryngitis.—This affection may arise from extension of inflammation from the pharynx, from exposure to cold and dampness, from the inhalation of irritating substances or gases, or from over-use of the parts in speaking or singing. The prominent symptoms are fever, cough, hoarseness or complete loss of voice, and more or less muco-purulent expectoration following frequent efforts to clear the throat. Dyspnœa is usually not present in these cases unless submucous œdema causes marked swelling of the inflamed mucous membrane. Laryngoscopic examination shows the mucous membrane of the larynx to be congested, red, and swollen, the cords being particularly involved. **Treatment.**—This consists in keeping the patient free from cold and exposure, at the same time leeches or cold compresses being applied to the neck over the larynx; and great relief is often experienced from the inhalation of steam impregnated with sedatives and astringent substances. A mixture of menthol, ℳxv, compound tincture of benzoin, fʒij, added to boiling water, Oi, is a very satisfactory inhalation. The use of an aperient is often followed by benefit. Under this treatment the affection usually subsides rapidly, and it is extremely rare for the breathing to be seriously affected. If dyspnœa should become marked from œdema of the mucous membrane, intubation or tracheotomy may be required.

Chronic Catarrhal Laryngitis.—This may result from acute laryngitis, the inhalation of irritating substances, or long-continued vocal efforts.

The symptoms are huskiness of the voice, with a constant desire to clear the throat, and the expectoration of a thick, tenacious mucus; laryngoscopic examination shows marked congestion and swelling of the mucous membrane. **Treatment.**—This consists in removing the cause of irritation as far as possible. When it is due to excessive use of the voice, rest should be secured; if due to the inhalation of irritating substances, this should be avoided, a change of occupation in many cases being necessary before a cure will result. The use of an alkaline spray, with the application of astringent substances to the inflamed parts, is often followed by good results.

Simple Membranous Laryngitis.—This was formerly considered a common affection of the larynx in childhood, and was described clinically as membranous croup. We now recognize that a membranous exudation may develop in the larynx and trachea as the result of inflammation due to burns, scalds, injuries, or foreign bodies, but that the cases of membranous exudation arising independently of these causes are of bacterial origin, being due to the presence of the Klebs-Loeffler bacillus, and are really cases of diphtheritic laryngitis.

Symptoms.—The symptoms of membranous laryngitis following non-infective inflammation are fever, restlessness, and gradually increasing dyspnœa, with cyanosis of the face. **Treatment.**—This consists in the use of an alkaline steam spray, the application of leeches or iced compresses to the neck over the larynx, and the administration of calomel in small and frequently repeated doses, and, if obstruction of the breathing becomes urgent, intubation or tracheotomy should be resorted to.

Tuberculous Laryngitis.—Primary tuberculosis of the larynx is a rare affection, but its occurrence secondary to pulmonary tuberculosis is not uncommon. Thickening of the mucous membrane first occurs, and soon minute ulcers are developed, which run together and cause large patches of ulceration. No part of the larynx is exempt from the disease, but the pyriform swelling of the mucous membrane covering the arytenoid cartilages, and the presence of ulceration upon the aryteno-epiglottic folds, false cords, and lower surface of the epiglottis, point very strongly to the tuberculous origin of the affection. When the ulceration is extensive the cartilages may be involved and necrosis may occur. **Symptoms.**—The symptoms of tuberculous laryngitis are those of chronic laryngitis, hoarseness of the voice with a frequent cough, pain and difficulty in swallowing; dyspnœa is not often marked unless acute œdema occurs. **Treatment.**—The patient should be placed upon treatment applicable for the tuberculous condition. Curetting of the ulcerated surface and the insufflation of iodoform are often employed with benefit, and the local use of medicated sprays may add much to the patient's comfort; if œdema develops and is followed by obstruction to the breathing, tracheotomy or intubation may be required.

Syphilitic Laryngitis.—This affection of the larynx may appear in the early or the late secondary stage or in the tertiary stage of the disease. In the early secondary stage there sometimes develops a laryngitis, corresponding to the sore throat noticed in this stage of the affection. In the tertiary stage, gummatous infiltration of the mucous and submucous tissues of the larynx occurs, which may break down, giving rise to typical gummatous

ulcers. The cartilages are frequently involved in the disease, and may be largely destroyed; and as the result of extensive ulceration and the subsequent cicatrization marked stenosis occurs. **Treatment.**—This consists in the administration of mercury or iodide of potassium in full doses, according to the stage of the disease, and the local use of antiseptic sprays or those containing mercury in solution. If acute œdema of the larynx, or stenosis from cicatricial contraction, develops, causing dyspnœa, intubation or tracheotomy may be demanded.

Diphtheritic Laryngitis.—This form of laryngitis, which is also described as membranous laryngitis, is characterized by inflammation of the mucous membrane of the larynx, with the deposit of a tough fibrous exudation or membrane, in which are incorporated pus-corpuscles and epithelial elements from the underlying mucous membrane. The membrane may develop primarily in the larynx, or it may spread to it secondarily from the pharynx, and may extend into the trachea and bronchi. (Fig. 731.) The invariable presence in the exudation of a special organism, the Klebs-Loeffler bacillus, has led to the recognition of this organism as the specific cause of the disease. This form of laryngitis is very common in children, but is rarely seen in adults, is often epidemic, and is accompanied by fever, a rapid pulse, enlargement of the submaxillary glands, and marked constitutional depression. **Symptoms.**—The symptoms of diphtheritic laryngitis are a croupy cough, suppression of the voice, gradually increasing dyspnœa, and cyanosis of the face, with restlessness; as the dyspnœa becomes more marked the patient sits up in bed and assumes the position in which the accessory muscles of respiration are brought into play. Inspection of the chest shows sinking in of the lower part of the chest and the upper part of the abdomen in inspiration, as well as of the tissues of the suprasternal notch and the supraclavicular spaces.

Fig. 731.

Tubular cast of membrane in larynx and trachea extending into the bronchial tubes.

Treatment.—This consists in the administration of bichloride of mercury, strychnine, and stimulants, and the patient should be given an easily assimilated and nutritious diet. The extensive use of antitoxine during the last few years has demonstrated its value, and it should be given hypodermically in doses of two thousand units, for a child three years of age, the injection being repeated within twelve or twenty-four hours if necessary, the action of the antitoxine being shown by the thinning and disappearance of the membrane, which usually occurs within from twenty-four to seventy-two hours. In addition to the constitutional infection in these cases there is often more or less dyspnœa, from the presence of the exudation and the swollen and œdematous condition of the mucous membrane of the larynx. If the dyspnœa is not urgent, we have found the use of a steam or hand spray of soda solution (Parker's solution), composed of carbonate of sodium, ʒi; glycerin, ℥i; water, f℥vi, to be followed by the most satisfactory results. This spray should be used at frequent in-

tervals, and in many cases we think its persistent use will obviate the necessity for operative treatment. If, however, the dyspnœa increases in spite of this treatment, intubation or tracheotomy should be promptly performed. These operations should not be postponed until the patient, exhausted by prolonged struggles for breath and imperfect aeration of the blood, is dying from cardiac failure.

Perichondritis and Chondritis of the Larynx.—These affections of the larynx are clinically difficult to differentiate, although chondritis is probably always preceded by perichondritis. Perichondritis and chondritis seldom are observed as primary affections, but usually follow an injury, or syphilitic, tuberculous, or cancerous ulceration, and occasionally are observed as sequelæ of typhoid fever or the exanthemata. The cricoid and arytenoid cartilages are those most commonly involved. When an abscess forms beneath the perichondrium, necrosis of the cartilage usually results, and the pus may be discharged into the larynx, or may perforate the cartilage and open into the tissues of the neck; a perforation involving the mucous membrane and the cartilage may be followed by emphysema of the neck. **Symptoms.**—These are similar to those of laryngitis, and consist of pain on pressure, in swallowing, and in phonation, hoarseness, cough, and in some cases rapidly developing dyspnœa. **Treatment.**—In the early stages of the affection leeches or an ice-bag may be employed, as well as medicated steam sprays. The difficulty in swallowing may be so great that for the proper administration of fluids and food the stomach-tube or enemata will be required. If under this treatment the symptoms do not improve and dyspnœa becomes marked, intubation or tracheotomy should be performed. External sinuses resulting from abscess may persist, and to obtain healing in these cases it is often necessary to lay them freely open and remove the necrosed cartilage.

Abscess of the Larynx.—This may arise from traumatism or develop in the course of typhoid fever or the exanthemata, but most frequently is a secondary affection following perichondritis or chondritis. The abscess may be situated within the larynx, occupying any portion of the organ, or it may be situated outside of the larynx. **Symptoms.**—The symptoms of intralaryngeal abscess are similar to those of perichondritis—pain, hoarseness, cough, difficulty in swallowing, and dyspnœa; if œdema of the larynx occurs, sudden suffocative symptoms develop. In extralaryngeal abscess pain and dysphagia are present, but dyspnœa is not often marked unless œdema of the larynx develops. A laryngoscopic examination in the case of an intralaryngeal abscess will often reveal the presence and seat of the abscess. Spontaneous evacuation of these abscesses often occurs, and is followed by marked relief of the symptoms; but in cases in which dyspnœa is well developed it is not safe to wait for this to take place. **Treatment.**—In intralaryngeal abscess, if the abscess can be exposed by the use of a laryngoscope, it should be promptly opened with a laryngeal knife or a director, if its walls are thin; if, however, dyspnœa is marked and the abscess cannot be exposed, tracheotomy should first be performed, and the abscess may be opened subsequently or allowed to rupture spontaneously. As soon as the abscess has been opened, the head should be low-

ered, to favor the escape of pus and prevent it from being drawn into the trachea. Extralaryngeal abscess should be opened by an incision in the neck over the seat of the purulent collection.

Ulceration of the Larynx.—Ulceration of the larynx may result from injury, from foreign bodies, from catarrhal, tuberculous, or syphilitic inflammation, or from malignant disease. It may involve only a limited amount of the surface of the larynx or may be widely extended; the vocal cords are very apt to be involved in the process. **Symptoms.**—These are practically those of laryngitis, and if the vocal cords are involved, hoarseness and loss of voice are noticed early. Cough with the expectoration of blood-stained mucus points to the presence of ulceration; dyspnœa is not apt to occur unless œdema develops as a result of the ulceration. **Treatment.**—This depends upon the cause of the ulceration, and rest of the affected part should be as far as possible maintained as a most important element in the treatment. Non-specific ulceration should be treated by alkaline sprays and the use of astringent powders or solutions, or nitrate of silver. In syphilitic ulceration, antisyphilitic remedies should be administered, and applications of mercurial solutions or of iodoform powder should be made to the ulcers. Tuberculous ulceration calls for change of air, good food, the administration of anti-tuberculous remedies, and the application of powder or solutions of iodoform and nitrate of silver to the ulcerated surface. Malignant ulceration is not markedly improved by local treatment, and, as a rule, calls for the performance of tracheotomy or excision of the larynx. In any of these forms of ulceration sudden dyspnœa may develop from œdema and may demand intubation or tracheotomy.

Stricture of the Larynx or Trachea.—Diminution of the calibre of the larynx or trachea from pressure from without is described as **compression stenosis**, and may arise from the pressure of tumors upon these organs, diminishing the calibre of the respiratory canal, or from deflection or kinking of the trachea from the presence of a growth in the neck in close relation with it. Tumors of the thyroid gland, enlarged lymphatic glands, and malignant growths of the neck often produce stricture or narrowing of the larynx or trachea in this manner. Stricture or narrowing of the calibre of these organs from within is described as **occlusion stenosis**, and may arise from cicatricial contraction following ulceration, from fracture of the cartilages, from wounds of the larynx or trachea, such as cut-throat wounds, or from inflammatory adhesions or tumors growing from the mucous membrane. **Symptoms.**—The symptoms of stricture of the larynx or trachea usually develop slowly, and consist in stridulous respiration and more or less dyspnœa, most marked in inspiration, varying with the amount of narrowing of the calibre of the larynx or trachea, and cyanosis of the face if the dyspnœa is urgent. The greatest danger in these cases arises from the occurrence of œdema, which may rapidly diminish the already obstructed breathing-space.

Treatment.—If the stenosis is due to pressure upon or to stricture of the larynx, the introduction of an intubation-tube may relieve the symptoms promptly, and by introducing tubes of different sizes gradual dilatation of the stricture may be accomplished. If, however, the symptoms of obstruc-

tive dyspnœa are very urgent, tracheotomy should be performed to relieve the immediate danger, and dilatation of the stricture should be practised later. When the dyspnœa arises from tracheal obstruction, if it is possible the trachea should be opened below the seat of obstruction; this may be difficult if the cause of the obstruction is a large tumor occupying the anterior portion of the neck, as little space may be left between the growth and the sternum. Tracheal obstruction due to goitre may require division of the tumor in the median line down to the trachea for its relief. When the obstruction is due to deflection or kinking of the trachea, the operation may be a most difficult one, as the trachea at the point where it is to be opened may be much displaced and its anatomical relations much disturbed.

TUMORS OF THE LARYNX.

Laryngeal tumors may be either benign or malignant: the great majority of such tumors fortunately belong to the former class.

Benign Tumors of the Larynx.—The most common varieties of tumors having their origin in the larynx are papillomata and fibromata, but cystic tumors, adenomata and angiomata, are occasionally observed in this location. Papillomata are the tumors most commonly observed, and are said to constitute fully two-thirds of all laryngeal tumors. They are quite frequently observed in children, but may also occur in adults who use the voice constantly, such as singers and public speakers, and are often multiple; they vary in size from that of a grain of wheat to that of a mass which fills the cavity of the larynx; they also have a marked tendency to recur after removal. Papillary tumors generally have their origin from the vocal cords. The tendency of benign tumors of the larynx in adults to be transformed into malignant growths is very marked; papilloma may be transformed into epithelioma, fibroma into fibrosarcoma, and adenoma into carcinoma.

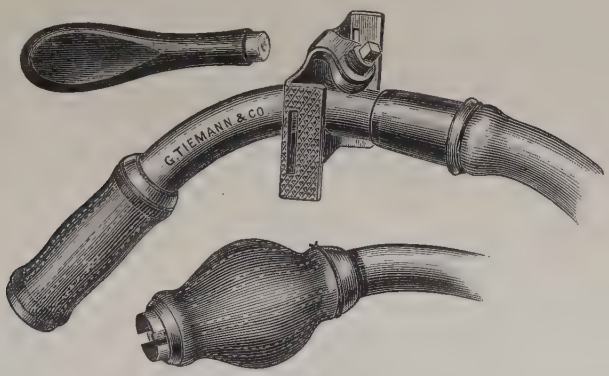
Symptoms.—Benign tumors of the larynx, as a rule, produce few symptoms other than hoarseness and partial loss of voice until they attain sufficient size to obstruct respiration or cause œdema of the adjacent parts. In children the expectoration of mucus tinged with blood, and hoarseness, even if dyspnœa is not present, should direct attention to the possible presence of laryngeal papilloma; pain is not usually present. The definite diagnosis of the condition can be made only by the laryngoscope, the use of which is often very difficult in young children. Many cases of papilloma in young children are recognized only when the dyspnœa becomes so marked that tracheotomy is required to prevent suffocation. Papilloma in adults well advanced in years may be easily confounded with epithelioma.

Treatment.—Various methods of treatment may be employed in the removal of benign growths of the larynx. The intralaryngeal method, by which the growth is exposed by the laryngoscope and is then removed by a snare or laryngeal forceps, is one of the best methods of treatment, but requires special skill in the use of these instruments, and is often impossible in the case of children, unless they have had considerable training to accustom them to their use. If dyspnœa is marked, attempts to remove the growth by the intralaryngeal operation should not be made, but the trachea

should be opened, and afterwards its removal accomplished by forceps or a snare. In adults the intralaryngeal method can often be employed with success. The tendency to recurrence of the growths requires this method of treatment to be prolonged for a considerable time. When the intralaryngeal method cannot be employed, as is often the case in children, or when it is important, for the purpose of diagnosis in adults between a benign and a malignant growth, to expose the growth, this may be accomplished by exposing the cavity of the larynx by an incision, thyrotomy.

Thyrotomy.—A preliminary tracheotomy should first be performed, and the trachea above the tube should be plugged with gauze, or a tampon tracheotomy-tube should be employed to prevent the entrance of blood into the trachea. This consists of a tracheotomy-tube whose lower portion is surrounded by a sac of india-rubber, which can be inflated when the tube is in place, and thus occludes the trachea above the lower opening of the tube and prevents the entrance of blood from above. (Fig. 732.) The

Fig. 732.



Tampon tracheotomy-tube.

thyroid and cricoid cartilages should be exposed by an incision in the median line of the neck, and the thyroid divided in the median line from its lowest portion to within a few lines of its upper limit, so that the alæ can be held apart by retractors. It is often necessary to divide the crico-thyroid membrane and the cricoid cartilage to obtain free exposure of the cavity of the larynx. When this has been accomplished, the growths may be removed by scissors or a curette, and their bases touched with chromic acid or the actual cautery; care should be taken to remove the growths thoroughly, as they have a great tendency to recur. After removal of the growths the edges of the cartilages should be brought together accurately by fine catgut sutures and the external wound should be closed by sutures. The tracheotomy-tube should be worn for a week or ten days, and as the tracheotomy wound closes the respiratory function is gradually restored to the larynx. Thyrotomy may also be employed to remove necrosed portions of the cartilages, or in cases of cicatricial stenosis following syphilitic or diphtheritic ulceration, when it becomes necessary to remove cicatricial tissue to increase the calibre of the larynx. The operation of thyrotomy is not attended with much risk, especially if a preliminary

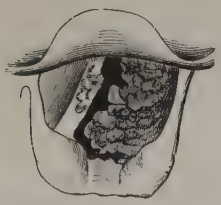
tracheotomy is done, and, if the cartilages are accurately brought together by sutures, prompt healing results, with little change in the voice.

MALIGNANT GROWTHS OF THE LARYNX.

The malignant growths met with in the larynx are sarcoma and carcinoma.

Sarcoma.—This is a rare growth in the larynx, and the diagnosis can be made only by removing a portion of the growth and examining it microscopically. Sarcoma of the larynx, if situated entirely within the cavity of the organ, should be treated by a preliminary tracheotomy, followed by thyrotomy to expose the growth, which should be thoroughly removed. The results following the removal of sarcomata of the larynx are more favorable than those following the removal of epitheliomata.

Fig. 733.



Epithelioma involving one side of the larynx. (Agnew.)

Epithelioma.—This disease may originate in the vocal cords or other parts of the larynx (Figs. 733, 734), or may involve the larynx by extension from the pharynx, and usually is observed between the ages of forty-five and sixty-five. The transformation of benign growths into epitheliomata is not uncommon.

Symptoms.—Epithelioma developing within the larynx may present the same symptoms as a benign growth, hoarseness and dyspnœa as the tumor increases in size, but soon neuralgic pain, dysphagia, and fixation and enlargement of the neighboring lymphatic glands occur. The most suggestive symptoms of epithelioma of the larynx are gradually developing hoarseness and a tendency to infiltration, with fixation of the vocal cord on the side of the disease. Laryngoscopic examination reveals the presence of an ulcerating growth, and if a portion of this is removed the characteristic structure of epithelioma is found. In cases where the larynx is involved secondarily no difficulty in the diagnosis can occur. In epithelioma of the larynx death results from exhaustion following the inability to take sufficient food, or from obstruction to the breathing, or from septic pneumonia.

Fig. 734

Epithelioma of the larynx. (Agnew.)

Treatment.—In cases of malignant disease of the larynx the treatment depends upon the conditions presented in individual cases. In many cases in which the larynx and the surrounding parts are extensively involved, or in those in which the disease has spread to the larynx from other parts, radical operative treatment cannot be considered. In such cases, as soon as dyspnœa is developed, a low tracheotomy should be performed and a tube introduced, which relieves the obstructed breathing, prolongs life for a considerable period, and ren-

ders the patient's condition comfortable until death shall result from extension of the disease, exhaustion, or septic pneumonia. When the disease is confined to the cavity of the larynx and involves only one side of the organ, and the neighboring lymphatic glands are not involved, the question of complete or partial excision of the larynx should be considered. When the tumor is so small that the operation can be limited to the removal of one-half of the larynx, the chances of recurrence are less, and the functional results as regards breathing and the preservation of the voice are often satisfactory. After complete excision the patient may be compelled to wear a tracheal tube, and often suffers much trouble from the saliva and food passing into the trachea, unless some of the recently devised methods of shutting off the communication of the larynx with the pharynx be adopted. Recurrence often takes place in a short time, but a number of cases have been reported in which the patients have lived for years and were in some instances able to breathe comfortably without a tracheotomy-tube, as in the case reported by Cohen.

Excision of the Larynx.—Excision of the larynx, partial or complete, is a most serious operation. Death may result from the operation itself, from shock or hemorrhage, or later from broncho-pneumonia, from purulent bronchitis, from the passage of food or blood into the trachea, or from septic cellulitis of the neck or the anterior mediastinum. Recurrence of the disease has commonly taken place in a short time, in spite of the complete removal of the growth, so that the advisability of the operation should always be carefully considered.

If excision of the larynx is decided upon, a low tracheotomy should be done some days before the operation upon the larynx is undertaken. Before the incision to expose the larynx is made, the cavity of the trachea above the tube should be packed with iodoform gauze, or a tampon tracheotomy-tube should be introduced. A long incision is then made in the median line of the neck, and the larynx freely exposed by blunt dissection; the thyroid cartilage is then split in the median line and the cavity of the larynx exposed. If the disease is confined to one side of the larynx, this should be removed; if the whole larynx is implicated, it should be carefully dissected out, bleeding being controlled as the dissection is made. When the entire larynx is removed, the opening in the pharynx should be closed by sutures, and the upper end of the trachea secured in the lower angle of the wound, thus completely shutting off the latter from communication with the pharynx. After the larynx has been removed, the wound should be lightly packed with iodoform gauze, and at the end of a few days the packing should be removed and replaced by a fresh one. The wound should be dressed daily, and great care taken to keep it aseptic. The patient should be fed for a few days by means of an œsophageal tube or by nutritious enemata. After partial removal of the larynx, the soft parts and the skin are closed by sutures, and after healing has occurred the tracheotomy-tube may be removed, and, if breathing is satisfactorily carried on through the larynx, the tube need not be replaced unless subsequent contraction makes its use necessary. After complete removal of the larynx, the tracheotomy-tube or some form of artificial larynx may have to be

worn continuously, but in some cases even these appliances may not be required.

Thyrotomy with excision of the growth, following a preliminary tracheotomy, is considered by some surgeons a more satisfactory procedure than excision of the larynx. When the growth is exposed it is carefully removed by dissecting it from the cartilaginous walls of the larynx, and the cartilages are not removed, as they are usually not involved until late in the disease. The wound is closed with sutures, and the tracheotomy-tube should be worn for some weeks until the union in the laryngeal wound is complete. The voice in these cases may be preserved to a certain extent.

Tumors of the Trachea.—The same varieties of tumors that are observed in the larynx may be found in the trachea, and, as in the larynx, papillomata and epitheliomata are those most commonly observed. Papillomata are usually pedunculated, while epitheliomata arise from the trachea by a broad base. They are generally situated at the upper portion of the trachea, and are most common in male adults. The principal symptom of tracheal tumor is dyspnœa without any marked affection of the voice. The latter symptom would point to the tumor's occupying the larynx rather than the trachea. In all cases a careful laryngoscopic examination should be made to prove that the growth does not occupy the larynx, and at the same time in many cases the tumor can be seen in the trachea.

Treatment.—This consists in performing tracheotomy as soon as the position of the tumor can be located or dyspnœa becomes marked. After tracheotomy the tracheal wound should be dilated, and in many cases the growth can be removed, when its base should be touched with chromic acid or the actual cautery. The tracheotomy-tube should be worn for some time, until it is evident that there is no tendency for the recurrence of the growth, and should then be dispensed with.

Tracheocele.—This consists of a hernia of the mucous membrane of the trachea between the tracheal rings, and may arise from a congenital defect in the trachea, or may follow subcutaneous rupture of the trachea from contusion or incomplete wound of the organ. The tumor may occupy the anterior or the lateral aspect of the trachea, and vary in size from that of a bean to that of an egg. The most marked symptom of this affection is the presence of a soft tumor which increases in size when the patient makes forced expiration with the mouth and nose closed, and can be diminished in size by manipulation; a certain amount of dyspnœa and change in the voice may be present. **Treatment.**—If the tumor is small and is attended by no discomfort, no special treatment is required. If, however, it is large and produces discomfort or marked change in the voice, pressure should be applied by means of a compress and bandage, and if this is not followed by good results the tumor should be exposed and excised, and the edges of the tracheal wound and the external wound closed by sutures.

FOREIGN BODIES IN THE AIR-PASSAGES.

The entrance of a foreign body into the larynx or trachea is an accident of frequent occurrence, and is most commonly observed in children. A body held in the mouth may suddenly be drawn into the larynx by an

inspiratory act, when it usually excites violent coughing and is soon expelled, or it may pass below the cords and enter the trachea or a bronchus. Various objects have entered the larynx and trachea and have been subsequently expelled or removed by operation—beads, pebbles, beans, pins, needles, coins, pencils (Fig. 735), particles of food, seeds of fruit, grains of corn, nuts, toys, etc. In Weist's collection of cases of foreign bodies in the larynx and trachea, in American cases a grain of corn was the body most frequently noted.

Fig. 735.

Lead-pencil impacted in larynx and trachea. (Cattell.)

Symptoms.—The symptoms following the entrance of a foreign body into the larynx or trachea are spasmodic cough, spasm of the larynx, and a feeling of suffocation. If the body is a large one, or is so situated that it obstructs the admission of air, urgent dyspnœa and cyanosis of the face soon develop, and if relief is not afforded by operation the patient perishes rapidly from suffocation. If dangerous symptoms do not develop immediately upon the introduction of the foreign body, the patient may be subject to recurrent attacks of suffocation if the body is a movable one and is carried up against or lodged in the glottis. Profuse muco-purulent expectoration may occur if the body has remained in the trachea or larynx for some time, and is accompanied by loud wheezing and râles heard over the trachea. The body, if a movable one, may at any time become impacted in the glottis, causing sudden death, or below the vocal cords, or in a bronchus. With an impacted foreign body the greatest respiratory difficulty is observed in inspiration, while if the body is movable the difficulty is most marked in expiration. The pressure of enlarged or caseating lymphatic glands of the mediastinum upon the trachea or upon a bronchus may produce symptoms resembling those caused by an impacted foreign body in these locations, and the possibility of this condition should not be lost sight of when the history of a foreign body entering the air-passages is indefinite.

Foreign Body in the Bronchus.—A foreign body is more likely to pass into the right bronchus than into the left, as the former more directly follows the line of the trachea; the septum at the bifurcation being to the left of the middle line. If the bronchus is only partially occluded, there will be noticed diminished expansion of the lung on the affected side, and a loud murmur at the seat of obstruction may be detected upon auscultation. If the bronchus is completely closed by the foreign body, resonance on percussion is at first present, but collapse of the lung, with retraction of the chest, soon appears. If the body is impacted in one of the divisions of the primary bronchus, the respiratory action of a limited area of the lung may be arrested. A body impacted in a bronchus may remain in place for some time and then become suddenly loosened by an attack of coughing and be arrested at the glottis, producing death by suffocation, or may be expelled

through the larynx. The pin shown in Fig. 736 was impacted in the right bronchus for twenty-three months, and was then coughed up and expelled, the patient making a good recovery. The termination of all cases is not so satisfactory as this, for the body may set up inflammation, abscess or gangrene of the lung may occur, and the patient may die of septic infection or of exhaustion following the free discharge.

Fig. 736.

Pin which was impacted in right bronchus.

Treatment.—When a foreign body has entered the air-passages and the symptoms are urgent, laryngotomy or tracheotomy should be immediately performed. The foreign body, if it be movable in the trachea, is often expelled by a violent expiratory effort as soon as the trachea is opened, or may be removed from the trachea or larynx with forceps. When the foreign body has been in the air-passages for but a short time and no inflammatory symptoms have developed, the wound in the trachea should be closed by sutures. If, on the other hand, the body has remained for some days in the trachea or larynx and has set up inflammation of these organs, as evidenced by the presence of râles and the expectoration of muco-purulent discharge, after the body has been removed a tracheotomy-tube should be introduced and worn for some days, until inflammation of the parts has subsided. If the foreign body cannot be located, a tracheotomy-tube should be introduced, and attempts at removal of the body made later. Inversion of the patient, with slapping of the back and chest, which is sometimes recommended, we consider an unsafe procedure, unless the trachea or larynx has been previously opened. In cases in which a foreign body has entered the air-passages, after the first symptoms of its presence have passed off and if the patient presents no urgent symptoms, careful laryngoscopic examination may reveal the location of the body, and it may be removed with laryngeal forceps; this method of treatment may be employed in adults, but is rarely possible in children.

It may be laid down as a safe rule of practice that as soon as it is certain that a foreign body is lodged in the air-passages tracheotomy should be performed, for there is always great risk to the patient until it is removed, since it may suddenly become movable and occlude the glottis or set up œdema, which may rapidly cause death. Its removal by the intralaryngeal method after tracheotomy can be postponed until the patient becomes accustomed to the use of the instruments required. In cases of a foreign body lodged in the bronchus, a low tracheotomy should be performed, and by means of delicate curved forceps, or a short silver probe whose extremity is bent to form a hook, the body may be dislodged and removed. If it cannot be removed in this way, inversion of the patient, with slapping of the chest, may be practised. If all these procedures are unsuccessful, the tracheotomy-tube should be worn to keep the wound open, and after some time the body may become loose and pass into the trachea, when it can be removed by taking out the tracheotomy-tube and dilating the wound. Where a foreign body is lodged in the bronchus its removal by external operation is possible, but the operation is an extremely difficult one, consisting in dissecting up a flap three inches square, with its base at the inner

border of the scapula, resecting the ribs, from the fourth to the eighth posteriorly at their angles, and detaching the pleura from its mediastinal attachments to the root of the lung, thus exposing the bronchus.

TRACHEOTOMY.

The operation of tracheotomy consists in dividing the tissues over the trachea in the median line of the neck, and, after the trachea has been exposed, opening it by dividing two or three of the tracheal rings. It may be required to relieve the dyspnœa dependent upon membranous or diphtheritic laryngitis, growths in the larynx or trachea, growths external to these organs, causing pressure upon them, and œdema of the mucous membrane of the larynx or trachea from inflammation, from burns or scalds, or from the inhalation of irritating gases or the swallowing of corrosive liquids. The operation may also be required for the removal of foreign bodies from the larynx or trachea, or from the bronchi, as well as for the relief of dyspnœa due to their presence. It is sometimes demanded in contusion, laceration, or fracture of the larynx or trachea, and occasionally in spasm of the glottis, and in glossitis, to overcome the mechanical obstruction which prevents the entrance of air into the air passages. The ease with which the trachea is exposed and opened varies much in different cases; as a rule, it is a much simpler operation in adults than in children. In children the shortness of the neck and the abundance of adipose tissue cause the trachea to be deeply seated, while the relatively greater size of the thyroid gland and the presence of the thymus body render the trachea difficult to expose and open.

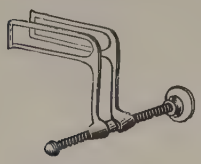
In an emergency the operation may be performed with very few instruments, but if the surgeon has the choice he will find it convenient to have at hand two small scalpels, one short grooved director, a tenaculum, two aneurism-needles, which may be used as retractors, hæmostatic forceps, two pairs of dissecting forceps, a pair of scissors, a sharp-pointed tenotome, a pair of tracheal forceps, a tracheal dilator, tracheotomy-tubes, tapes, ligatures, sponges, a flexible catheter, and feathers. The *director* should be short, the ordinary grooved director being too long to use with satisfaction in operating upon the short necks of children. We employ a short, broad director with a bevelled extremity, which allows it to be passed with ease between the different layers of the tissues. (Fig. 737.) Hæmostatic forceps are of great use in controlling hemorrhage during the operation. A sharp-pointed *tenotome* is the instrument we prefer to employ in opening the trachea, as its sharp point enables it to be easily thrust into the trachea, and its short cutting surface and the narrowness of the blade obscure as little as possible the line of incision, thus enabling the operator to see exactly where he is cutting. *Tracheal dilators* of various kinds are employed, but the most satisfactory tracheal dilator is that of

Fig. 737.

Tracheotomy director.

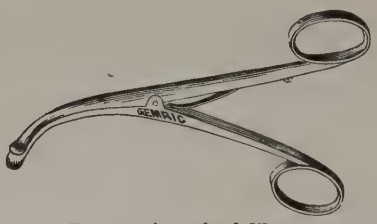
Golding-Bird, which is a self-retaining instrument. (Fig. 738.) Trousseau's tracheal dilator is also a satisfactory instrument. (Fig. 739.) Tracheal dilators may be improvised from bent hair-pins or pieces of wire, which will often serve a useful purpose when the ordinary dilators cannot

Fig. 738.



Golding-Bird's tracheal dilator.

Fig. 739.



Trousseau's tracheal dilator.

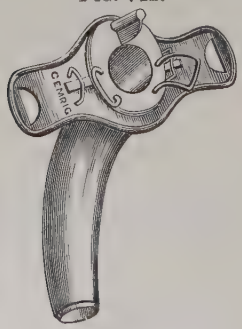
be obtained. It is also well to have at hand a number of pliable feathers to use in clearing the trachea or the larynx of mucus or membrane after it has been opened, as by their use this object can be accomplished with little risk of injury to the mucous membrane. *Tracheal forceps*, constructed with a

Fig. 740.

Tracheal forceps.

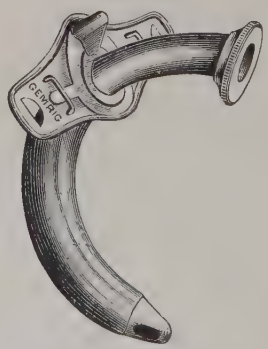
double spring and curved blades, are also useful in removing membrane or foreign bodies above the wound, or from the trachea below the incision. (Fig. 740.) *Tracheotomy-tubes* are of various shapes, and are made of silver, aluminum, and hard rubber, but the tube which we think is the

Fig. 741.



Tracheotomy-tube.

Fig. 742.



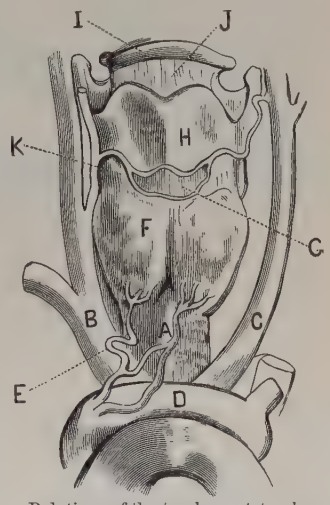
Tracheotomy-tube with fenestrated guide.

most satisfactory for general use is a silver quarter-circle tube, without a fenestra, and with a movable collar (Fig. 741) which should be provided with a fenestrated guide to facilitate its introduction. (Fig. 742.) The

tracheotomy-tube is held in position after it is introduced by means of tapes attached to the shield of the tube and tied around the neck. The size of the tube to be employed varies with the age of the patient. In adults a No. 5 or No. 6 tube is required; in children under two years of age a No. 2 tube, from two to four years a No. 3 tube, and over four years a No. 4 tube, is generally used.

Anatomy of the Anterior Region of the Neck.—In making an incision over the trachea in the median line of the neck, as soon as the skin has been divided the superficial fascia is exposed, beneath which is the deep cervical fascia which encloses the sterno-hyoid and sterno-thyroid muscles. Upon opening the superficial fascia a large superficial venous trunk, the *superficial anterior jugular vein*, may be met with, or there may be two veins running parallel with the trachea, one on each side of the median line, and communicating by a large transverse branch at the lower part of the neck. A large plexus of veins also surrounds the isthmus of the thyroid, opening above into the superior thyroid and below into the inferior thyroid vein. The *innominate vein* on the left side occasionally rises above the level of the sternum. (Fig. 743, *D.*) The *sterno-hyoid* and *sterno-thyroid* muscles at their upper attachment are not quite in contact, and as they descend the neck they are further separated; the space between them, which occupies the median line of the neck, is an important guide to the operator. The *arteries* of the neck which are of most importance in the operation are the *crico-thyroid*, a branch of the *superior thyroid*, and the *thyroidea-ima*, an irregular branch from the aortic arch or from the innominate. In children the innominate artery occasionally rises into the pre-tracheal space. The isthmus of the *thyroid* gland is generally largely developed in children, often covering the second and third rings of the trachea, and in some cases extending higher and covering the cricoid cartilage. The *thymus* gland in children under two years of age may be exposed in opening the trachea below the isthmus of the thyroid gland. The *trachea* begins at the lower border of the cricoid cartilage and terminates opposite the fourth dorsal vertebra, although its surgical limit is the upper border of the sternum. It is covered by the tracheal fascia, and is most superficial near the cricoid cartilage; it is more movable in children than in adults. Its size varies in different individuals of the same age, being larger in males than in females. The diameter of the trachea under eighteen months of age is about four millimetres; from two to four years of age, eight millimetres; and from eight to twelve years, ten millimetres.

Fig. 743.



Relations of the trachea: *A*, trachea; *B*, innominate artery; *C*, left carotid artery; *D*, innominate vein; *E*, thyroid plexus; *F*, thyroid body; *G*, crico-thyroid membrane; *H*, thyroid cartilage; *I*, hyoid bone; *J*, thyro-hyoid membrane; *K*, crico-thyroid arteries. (Agnew.)

Position of the Patient for Tracheotomy.—The most satisfactory position is that which brings the neck into the greatest prominence, and this can best be obtained by laying the patient upon his back on a firm table, and placing under the shoulders a round cushion, or an empty wine-bottle, or a roller-pin wrapped in a towel. (Fig. 744.) In cases of great emergency, where there is no time to place the patient in this position, we have found that the trachea can be rendered more superficial by allowing the head to drop over the edge of a table or the end of a lounge.

Fig. 744.

Position of patient for tracheotomy.

The Use of an Anæsthetic in Tracheotomy.—As a rule, we think it is better not to administer an anæsthetic in performing this operation, as little pain is experienced, in cases in which the dyspnœa is well marked, after the incision in the skin has been made. We object to the use of an anæsthetic from the fact that we have seen the dyspnœa, which was not urgent before the use of the anæsthetic, suddenly, under its employment, become alarming, or the breathing cease altogether, so that the trachea had to be opened before it was thoroughly exposed, which is a procedure always attended with risk.

So strong is our conviction that the risks of the operation are much increased by the employment of an anæsthetic that of late years we have abandoned its use entirely. In adults we often employ a two per cent. solution of cocaine hypodermically, but in children its use is not accompanied by good results, as their struggles are probably caused as much by restraint and the terror produced by the manipulations as by actual pain.

Indications for Tracheotomy.—The prominent symptom calling for tracheotomy is obstructive dyspnœa, characterized by suppression of the voice, great difficulty, usually, in inspiration, lividity of the lips, depression of the suprasternal and supraclavicular spaces, sinking in of the lower part of the chest, inability to breathe in the recumbent posture, and great restlessness. The mistake should not be made of confounding labored breathing, which is always present in cases where there exists mechanical obstruction to the entrance of air into the lungs. with frequent breathing, which depends upon diminished air-capacity of the lungs.

The trachea may be opened above the isthmus of the thyroid gland or below it, and these operations constitute respectively the high and the low operation. The **high** operation of tracheotomy is generally selected, because at this point the trachea is very superficial and is more easily exposed; it should therefore be preferred in the case of young children, when the dyspnœa is urgent and time is an important element. The **low** operation is the one in which the trachea is opened below the isthmus of the thyroid gland. In this region the trachea is more difficult to expose, by reason

of its relatively greater depth, the large size and number of the veins covering it, and its proximity to the large veins and arterial trunks at the root of the neck. The low operation should be preferred for the removal of a foreign body impacted in a bronchus, or when tracheotomy is required to relieve dyspnœa caused by a tumor of the thyroid gland or other growth pressing upon the upper portion of the trachea.

Operation.—The patient being placed in position, shown in Fig. 744, an assistant holds the head firmly, so that it cannot be tossed from side to side, while another assistant, standing at the side of the patient, secures his arms and prevents him from slipping off the pad upon which his shoulders rest. The operator next makes an incision through the skin in the median line of the neck, from one and a half to two inches in length, the position of the cricoid cartilage being the middle point. Having divided the skin, he will often see large veins lying in the superficial fascia. These should be displaced and the fascia divided between them upon the director. The surgeon should keep his incisions strictly in the median line of the neck, for this is the line of safety, and should be careful, as the wound increases in depth, not to make the incision too short, so that it becomes funnel-shaped. When the deep fascia is exposed it should be picked up and divided upon a director, and any enlarged veins in the line of the wound displaced or ligated on each side and divided between the ligatures. The operator next looks for the intermuscular space between the sterno-hyoid and sterno-thyroid muscles, which can generally be found without difficulty, and the muscles are separated in this line with the handle of a knife or with a director, when the isthmus of the thyroid gland will be exposed. The muscles should now be held aside by retractors placed on each side, care being taken that the movable trachea is not included in the grasp of the retractor, which would shut off respiration. This accident has occurred, and the cervical vertebræ have been exposed, in searching for the trachea.

If the case is not an extremely urgent one, the surgeon should proceed with deliberation, and carefully explore the wound with the finger to locate exactly the position of the trachea, and to ascertain, if possible, the presence of anomalous arteries. The isthmus of the thyroid gland having been exposed, occupying a position over the first three tracheal rings, is usually found surrounded by a plexus of veins, which should be displaced with a director or ligated on each side and divided between the ligatures. The thyroid isthmus is next drawn upward or downward, according as the surgeon desires to open the trachea below or above this body ; this can often be done without difficulty, especially its displacement upward. Having displaced the isthmus of the thyroid gland, the trachea, yellowish white in appearance, covered by the tracheal fascia, will be exposed. This fascia should next be thoroughly broken up with a director or the handle of the knife, so as to bare the trachea, and in doing this the operator can feel the fascia crepitate under the finger from the presence of the air drawn in with inspiration.

The operator should now examine the wound, to see that it is free from hemorrhage, and replace the retractors, so as to expose as large a portion as

possible of the trachea, for, be the case ever so urgent, he now feels assured that he can open the trachea in a moment if the breathing should cease. The trachea is next fixed with a tenaculum, introduced a little to one side of the median line, and an incision is made into it with a narrow knife from below upward, from one-half to three-fourths of an inch in length, care being taken that this incision is in the median line of the trachea, for if it be opened by a lateral incision the wound will not heal so promptly, and the tracheotomy-tube will not fit well. If the trachea be deeply seated, after fixing it with a tenaculum it may be lifted slightly from its bed, thereby making it more superficial in the wound.

As soon as the incision is made in the trachea there is a gush of air from the wound, mixed with blood or membrane; this should be wiped away with a sponge, a tracheal dilator introduced, and the trachea cleared of membrane, if it is present in the region of the wound, with a feather or with forceps; the tracheotomy-tube is next introduced, and is secured in position by tapes tied around the neck. If a tracheotomy tube is not at hand, the tracheal wound may be kept open by suturing the edge of the trachea on each side to the skin. It is not unusual after the trachea has been opened to have a sudden arrest of respiration; this, although alarming, is usually only momentary. If the patient's face and chest be slapped with a wet towel, or if artificial respiration be employed, normal respiratory movements will soon be re-established. A sudden arrest of respiration during the operation is a most dangerous symptom, calling for prompt action on the part of the operator. The surgeon's duty under such circumstances is to open the trachea as rapidly as possible, introduce a tracheal dilator, and make artificial respiration.

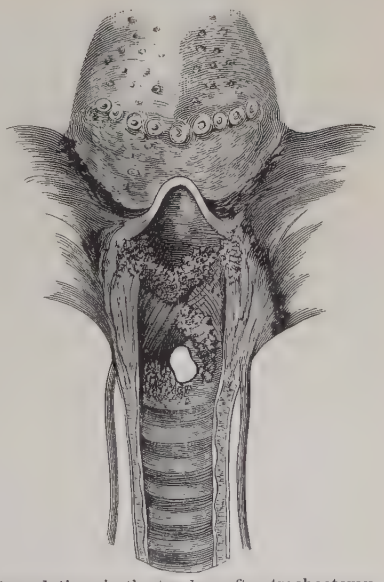
After-Treatment of Tracheotomy.—After the trachea has been opened and the tube has been inserted, if the operation has been done for an inflammatory condition of the larynx or trachea it is well to have the patient kept in a moist atmosphere. This may be accomplished by having a steam spray, or a spray composed of the soda solution given below, constantly playing in the room, or a croup tent may be formed around the bed or cot by securing a wooden framework to the cot and covering this with sheets; under this tent the use of a small steam spray will keep the air in a moist condition.

Care of the Tracheotomy-Tube.—The care of the tracheotomy-tube is a matter of great importance; the inner tube should be removed at short intervals, washed, and replaced; a moistened feather should occasionally be passed through the tube into the trachea to withdraw any mucus or membrane which is present. In these cases the use of a spray of steam, or a spray composed of carbonate of sodium, ʒi to ʒij; glycerin, ℥i; water, ℥vi, applied by means of a steam atomizer, the spray being directed over the opening of the tube, will be found most satisfactory in softening the membrane and thus facilitating its expulsion through the tube. The tracheotomy-tube is usually allowed to remain in the trachea for from five to ten days, being changed at intervals of two or three days, and its permanent removal is indicated as soon as the patient is able to breathe through the larynx with the wound in the trachea closed. After its removal the wound

rapidly diminishes in size; for a few days air escapes from it upon coughing, but the wound is usually permanently healed at the end of a week.

Complications after Tracheotomy.—Diphtheritic Infection of the Wound.—Diphtheritic infection of the wound is a complication occasionally seen after tracheotomy for diphtheritic laryngitis, and is one which is grave, although not necessarily fatal. The *treatment* of this condition consists in the local application of peroxide of hydrogen and the subsequent curetting of the surface of the wound and swabbing it with a solution of 1 to 500 bichloride of mercury. **Secondary Hemorrhage.**—This is a rare complication after tracheotomy, but may arise from vessels divided or injured during the operation, or from ulcerative perforation of the trachea through pressure of the lower extremity of a badly fitting tracheotomy-tube, causing erosion of the great vessels of the neck. Its *treatment* consists in ligating the bleeding vessels. **Surgical Emphysema.**—This affection is occasionally met with after tracheotomy, the air being sucked into the tracheal fascia and diffused through the tissues. It is more common after tracheotomy in which the incision in the trachea is not in the median line and does not correspond with the wound in the soft parts in front of the trachea. A moderate amount of emphysema in the immediate neighborhood of the wound is not uncommon, but sometimes the condition is developed to such an extent that the cellular tissues of the neck, face, arms, chest, and abdomen become greatly distended with air. The most fatal form of emphysema after tracheotomy is that of the connective tissue of the mediastinum, constituting what is known as *mediastinal emphysema.* Emphysema of a moderate extent seems to do no harm, as the air is quickly absorbed; but when it becomes general and the mediastinum is involved, marked dyspnœa is apt to develop, and the prognosis is extremely grave. **Tracheal Granulations.**—Granulations about the tracheal wound occur in certain cases where it is necessary to wear the tube for a considerable time, or where the mucous membrane seems to be in a peculiar hypersensitive condition. The presence of granulations may be suspected if the patient coughs up blood-stained secretions after the tube has been changed. Withdrawal of the tube and inspection of the wound will often disclose the presence of granulations attached to the edges of the tracheal wound or growing from the trachea in the region of the wound. (Fig. 745.) The *treatment* of this condition consists in the removal of the tube and in the application of a thirty-grain solution, or the solid stick of nitrate of silver, or the granulations may be removed with forceps and scissors. **Ulceration.**—

Fig. 745.



Granulations in the trachea after tracheotomy. (Parker.)

Ulceration of the trachea may arise from improperly shaped or badly fitting tracheotomy-tubes; it may be suspected when the tube, if a silver one, becomes blackened and there are fetor of the breath and expectoration of purulent and blood-stained discharge. The *treatment* consists in removing the badly fitting tube and replacing it by a proper one, and applying to the ulcerated surface a ten-grain solution of nitrate of silver.

Difficulty in the Permanent Removal of the Tracheotomy-Tube.—This is due in some cases to mechanical causes, such as the growth of granulations in the trachea or the wound, or in the larynx, inflammatory hypertrophy of the vocal cords, adhesion between the cords, paralysis of the posterior crico-arytenoid muscles, spasm of the glottis, or stenosis of the trachea above the seat of operation. In other cases the operation seems to produce irritability and disordered action of the muscles of the glottis, interrupting their usual rhythm, the patient being somewhat in the position of one with paralysis of the vocal cords. In many cases mental agitation plays an important part in preventing the removal of the tube. We have often seen children who could breathe comfortably through the larynx when the tube was plugged, who, when it had been removed and the tracheal wound had been closed with a pad or an obturator, exhibited great mental agitation, and developed such alarming symptoms of dyspnœa that the re-introduction of the tube became necessary. In such cases the fright caused by the removal of the tracheotomy-tube often produces a nervous and excitable condition, with irregular respiration, and sobbing, which seems to induce spasm of the glottis. The permanent removal of the tracheotomy-tube, even when much delayed, should not be despaired of. The tube should be removed at intervals and replaced as soon as symptoms of dyspnœa appear; a most satisfactory method of removing the tube in these cases consists in introducing an intubation-tube into the larynx, which is worn until the wound in the trachea has healed.

Tracheotomy in Adults.—The operation of tracheotomy in adults, whether performed for inflammatory conditions, for pressure upon the trachea, or for foreign bodies in the trachea, is usually a much simpler operation than in infants or children, for the reason that the surgeon has the co-operation of the patient, and the trachea is more superficial. The steps of the operation are very similar to those in the operation upon children. The most difficult tracheotomies in adults are those in which the operation is done for stenosis of the trachea or larynx produced by tumors of the neck. In such cases a very limited portion of the trachea may be accessible for operation, or it may be so much displaced by the growth that its anatomical relations are greatly disturbed.

LARYNGOTOMY.

This is an operation in which an opening is made into the larynx through the crico-thyroid membrane, and is more frequently employed in adults than in children. It is a simple operation, and can therefore be performed much more rapidly and safely in urgent cases than tracheotomy. The patient being placed in the recumbent posture, with the shoulders slightly elevated and the head thrown back to make the neck as prominent as pos-

sible, the surgeon feels for the prominence of the thyroid cartilage, and, steadying the larynx with the finger and thumb of the left hand, he makes an incision in the median line from the centre of the thyroid cartilage, extending downward for an inch or an inch and a half; the skin and superficial fascia being divided, the fascia between the sterno-hyoid muscles and the areolar tissues should be severed, and the crico-thyroid membrane is exposed. The knife is then passed transversely through the membrane into the larynx, care being taken that both this membrane and the mucous membrane which covers its inner surface are divided at the same time. As soon as the knife enters the cavity of the larynx, blood and mucus will be forcibly expelled. The only bleeding which is likely to occur is from the crico-thyroid arteries or veins; if these cannot be avoided, and are divided, they should be temporarily secured by hæmostatic forceps or ligatured, and, if the case is not extremely urgent, all hemorrhage should be arrested before the crico-thyroid membrane is incised.

The **after-treatment** of cases of laryngotomy is similar to that of cases of tracheotomy, and the same attention is required in the care of the tube and in the general management of the patient. If the operation is done for a foreign body impacted in the larynx, the wound should be dilated, and the foreign body removed with forceps; if done for the relief of an inflammatory condition of the larynx, it may be necessary to introduce a tube into the wound for a few days. The tube employed in laryngotomy differs from the ordinary tracheotomy-tube in being slightly flattened.

Laryngo-Tracheotomy.—This operation consists in making an incision which divides one or two of the upper rings of the trachea, the crico-tracheal membrane, the cricoid cartilage, and the crico-thyroid membrane. It may be employed in cases in which, from the age of the patient, the crico-thyroid space is too small to admit of a sufficient opening, or in those in which for any reason the surgeon does not deem it advisable to attempt to open the trachea lower down. The incision in the skin and the superficial fascia of the neck is made in the same manner as in the operation of laryngotomy, but is carried a little farther downward. It may also be necessary to displace the isthmus of the thyroid gland downward as the wound is deepened, to expose the upper portion of the trachea. When the trachea has been exposed, it should be opened by making an incision through it and the cricoid cartilage from below upward. After the trachea and cricoid cartilage have been divided, a tracheotomy-tube should be introduced into the wound; and the after-care of the case is similar to that of a case of tracheotomy.

INTUBATION OF THE LARYNX.

This is an operation in which a metallic tube is passed through the mouth into the larynx and allowed to remain there for a certain period, for the relief of dyspnœa resulting from laryngeal stenosis. Intubation of the larynx has recently been widely practised in the treatment of inflammatory affections of the larynx as a substitute for tracheotomy, and is generally employed to relieve dyspnœa in diphtheritic and membranous croup, in stricture of the larynx, and occasionally in œdema of the glottis. Intu-

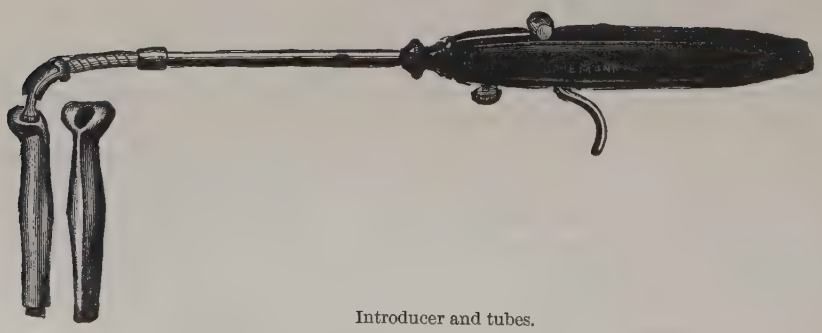
bation has been recommended in cases of foreign bodies in the larynx or in the trachea, but in such cases tracheotomy should be preferred. The indications for intubation of the larynx are similar to those for the operation of tracheotomy.

Prognosis in Intubation.—The number of recoveries following this operation is very similar to the number following tracheotomy. Ball, in a collection of 4217 cases of intubation, gives 1285 recoveries, or about $30\frac{4}{10}$ per cent. The number of successful results following intubation in the first and second years of life is certainly greater than that following tracheotomy. It must be remembered, however, that the statistics of intubation compared with those of tracheotomy are not absolutely to be relied upon, for many operators perform intubation at a time when the dyspnœa is not extremely urgent, while they would hesitate to perform tracheotomy: so that it is possible that many of the milder cases are intubated, while the very urgent ones are reserved for tracheotomy. The results following intubation in cases of diphtheritic laryngitis seem to be more encouraging since the use of antitoxine in this affection has become more general.

Instruments required for Intubation.—The instruments required for intubation are—

Intubation-Tubes.—The intubation-tubes for children are usually six in number, of different sizes, adapted to children from one to twelve years

Fig. 746.



Introducer and tubes.

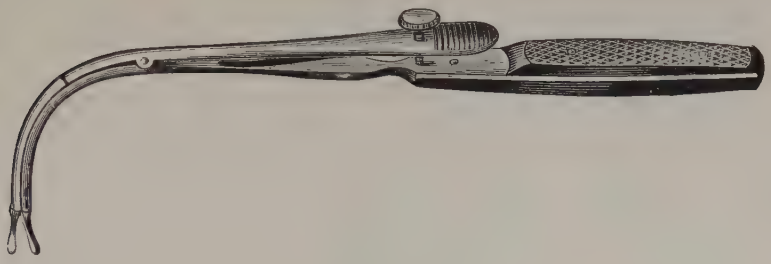
of age. The tube now generally employed consists of a metal cylinder which bulges near its centre and is provided with a collar or head to rest upon the false vocal cords. The tubes are gold-plated, and each is provided with an obturator which has a blunt extremity, and through the edge of the collar on each tube there is a small perforation, into which a strand of fine braided silk is passed: this serves to remove the tube if in its introduction it should be passed into the pharynx or the œsophagus instead of the larynx, or if owing to sudden obstruction it has to be hurriedly withdrawn. **The Introducer.**—This instrument consists of a handle and a staff, curved to a right angle at

Fig. 747.

Mouth-gag.

its extremity, which has a screw that attaches it to the obturator, and a sliding gear for detaching the obturator from the tube when it is placed in the larynx. (Fig. 746.) **Mouth-Gags.**—Mouth-gags of various kinds may be used; the one generally used is a self-retaining instrument. (Fig. 747.) **The Extractor.**—The extractor is also curved on a right angle, and has

Fig. 748.



Extractor.

at its extremity a small forceps with duckbill blades, which are made to separate and apply themselves to the interior surface of the tube with sufficient firmness to withdraw it. (Fig. 748.) **The Gauge.**—The gauge is to determine from the age of the child the size of tube to be employed. (Fig. 749.)

Preparation for Intubation.—It is important that the following preparations should be made, so that the actual introduction of the intubation-tube may occupy as little time as possible, for it should be remembered that when an intubation-tube enters the larynx breathing is arrested until the obturator is removed, and therefore all manipulations should be as rapid as is consistent with accuracy. The time usually required, after the mouth-gag has been adjusted, for the introduction of the intubation-tube and withdrawal of the obturator is from five to ten seconds. The surgeon should select a tube of suitable size for the age of the patient, and pass a strand of fine braided silk, about two feet in length, through the opening in the collar of the tube and secure it with a knot. Having attached the tube by means of the obturator to the introducer, he should see that it can be freed from the obturator by working the slide. The surgeon next protects the index finger of the left hand, in the region of the second joint, by wrapping it with a piece of rubber plaster or by slipping over it a metal shield. This is an important precaution to prevent the patient from biting the finger in case the mouth-gag should slip, for a bite from the teeth, which are often very foul in these cases, is liable to be followed by very serious consequences.

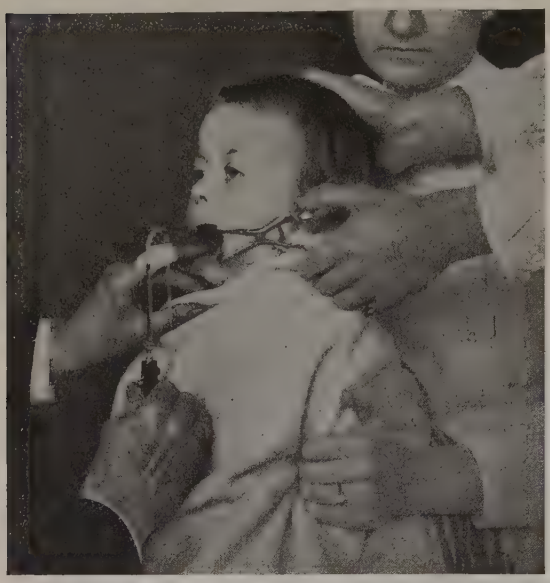
Fig. 749.

Gauge.

Operation.—The child should be placed in a sitting position upon the lap of the nurse or assistant, and covered by a blanket loosely thrown around it. The nurse grasps the child's elbows outside of the blanket and holds them firmly, but should not press them against the chest in such a way as to embarrass the respiratory movements; at the same time

the legs of the patient should be secured by being held between the knees of the nurse. The head of the patient is next secured by being held between the open hands of an assistant placed upon each side of the head and cheeks; the left hand of the assistant may also be used in steadying the mouth-gag after it has been introduced. (Fig. 750.) It is possible to introduce the tube with the child in the recumbent posture; this we have done on several occasions when from the condition of the circulation we did not think it advisable to lift the patient to the sitting posture.

Fig. 750.



Intubation of the larynx.

The child being held as described above, facing the surgeon, who sits upon a chair within easy reach of the patient, he opens the mouth and introduces the blades of the mouth-gag between the molar teeth upon the left side; the blades are next opened by compressing the handles of the gag, and the mouth opened as widely as possible. The surgeon passes the index finger of the left hand into the pharynx and feels for the epiglottis, which is hooked forward by the end of the finger. The tube attached to the introducer, held in the right hand, is next passed into the mouth and carried back to the pharynx, the operator being careful to see that it hugs the base of the tongue in the middle line, that the handle is depressed well upon the child's chest, and that the silken thread is free. When the extremity of the tube comes in contact with the end of the finger resting upon the epiglottis, the handle should be raised as it engages in the larynx and descends into this organ; and as it is pushed downward into place, the finger is placed upon the head of the tube to fix it and prevent its being withdrawn with the obturator. The trigger is next pressed, the introducer and obturator are drawn from the mouth by depressing the handle upon the chest, and before removing the finger it is well to push the tube well into the larynx.

As soon as the obturator is removed there is generally a violent expiratory effort, with coughing, accompanied by a gush of muco-purulent matter or membrane from the tube, and after this escapes the breathing is usually satisfactorily established. If the operator has passed the tube into the pharynx or the œsophagus, and has detached it from the introducing instrument, no improvement in the respiration takes place, and it should then be withdrawn by the silk loop and attached to the obturator, and another attempt made to introduce it into the larynx.

The mistake which inexperienced operators make in attempting to introduce the intubation-tube consists in not hugging the posterior surface of the tongue closely, so that they pass the tube over the epiglottis into the pharynx. The most serious complication which is apt to occur during the introduction of the intubation-tube is the detachment and pushing of a mass of membrane in front of the tube into the trachea. If this is too large to be expelled through the tube, the breathing is suddenly arrested; the tube should then be removed at once, and if the mass of membrane does not escape upon the expiratory efforts of the patient, the trachea should be rapidly opened. So much do we dread this accident, which has occurred to us in one case only, that we never introduce an intubation-tube without having at hand the necessary instruments to do a tracheotomy if it should be suddenly required.

Some operators keep the loop attached to the tube during the time it is retained in the larynx, so that by drawing upon it the nurse or attendant is able to withdraw the tube instantly if it should become obstructed with membrane, or be coughed up, and pass into the pharynx or the œsophagus. If it is decided to allow the silk loop to remain in place, it is well to sink the strands well down to the gum between the first molar and premolar teeth of the lower jaw, to prevent the silk from being bitten in two by the child, which often occurs if it is left free in the mouth. As the presence of the silk string usually causes much irritation of the pharynx, we prefer to withdraw it as soon as the tube is securely placed in the larynx, and remove the tube by means of the extracting instrument when its removal is required. We generally allow the string to remain in place for ten or fifteen minutes, securing it loosely about the ear, and at the end of this time, if the coughing has diminished and the tube has not been expelled, we introduce the finger into the mouth and feel that the tube is in its proper place, and then, while the tip of the finger rests upon the edge of the tube, divide the silk loop and withdraw it.

After-Treatment.—After the operation of intubation the patient should, if possible, be kept in a warm room in which a certain amount of moisture is maintained by the use of boiling water or by a steam spray. If there is little tendency to expectoration through the tube, the soda solution previously mentioned may be employed with advantage. One of the greatest troubles after intubation of the larynx is the satisfactory feeding of the patient and the administration of liquid medicines. Liquids, as a rule, are not swallowed well, a portion of them escaping into the tube and producing violent coughing. Cases are occasionally met with in which the swallowing of liquids does not seem to be seriously interfered with by the presence of the intubation-tube, but in the majority of cases this symptom is a troublesome one. We usually order a diet of semi-solids, such as corn-starch, soft-boiled eggs, mush, and junket, which are often swallowed without difficulty. The taking of a sufficient quantity of water often causes trouble, and in such cases the child may be allowed to swallow small pieces of ice, or water may be regularly administered by the rectum. In cases where there is difficulty in swallowing even this form of diet, it may be necessary to resort to nutritious enemata or the use of the stomach-tube for a few days.

In young patients, in whom a liquid or milk diet is essential, if the head is dropped a little lower than the body during the act of deglutition it will often be found that the fluids are swallowed without difficulty. (Fig. 751.)

Fig. 751.

Feeding a case of intubation.

Removal of Intubation-Tubes. — The intubation-tube usually remains in place about a week, but may be coughed out sooner if the swelling of the laryngeal tissues subsides before this time. We usually remove the tube at the end of a week, and if the breathing is satisfactorily carried on for half an hour and no dyspnœa appears, its reintroduction may not be necessary. If, however, after the tube has been out a few minutes dyspnœa returns, the tube should be promptly reintroduced, and its removal should not be attempted again for three or four days. In many cases the tube is coughed out within one week from its introduction, and its reintroduction is not often required in these cases. The tube can usually be permanently dispensed with in from five to ten days, although we have had cases in which it could not be permanently removed until the fifteenth day. Cases have been reported in which the tube had to be worn for many months, the conditions in these cases preventing the permanent removal of the tube probably being similar to those which cause delay in the removal of tracheotomy-tubes. After an intubation-tube has been coughed up or removed, the patient should be carefully watched for from twelve to twenty-four hours, for the dyspnœa may recur at any time within this period and require replacement of the tube. The surgeon should therefore be always within easy reach of the patient during this time.

After intubation of the larynx very decided hoarseness often persists for several weeks, but after this time usually entirely passes away.

Comparative Value of Tracheotomy and Intubation.—A considerable experience with both of these operations in the treatment of croup has led us to believe that intubation possesses certain advantages in the earlier stages of this affection, and that it is indicated in cases of diphtheritic or membranous laryngitis in which the disease has not lasted for a long time, and in which there is no marked swelling of the tonsils or pharynx; whereas in cases in which there is evidence of well-marked organized membrane upon the tonsils or the pharynx, extending into the larynx, or in which there is marked swelling of the tonsils and the pharynx, causing obstruction, we consider tracheotomy the better operation.

Intubation in Cicatricial Stenosis of the Larynx.—The introduction of an intubation-tube in cases of stenosis of the larynx resulting from cicatrization following wounds or injuries, or following the pressure of growths upon the larynx, or in cases where there is difficulty in the removal of the tracheotomy-tube, may often be employed with advantage. When intubation-tubes are introduced for stenosis of the larynx, they are employed not only to relieve the dyspnœa, but also as dilators, and, therefore, the tubes should be removed at intervals and replaced by larger ones. In such cases the larynx seems to bear the presence of the tube remarkably well, and it may be allowed to remain for a week or ten days without removal. It should be removed, however, at this time, and replaced by a tube of greater size if there is evidence that its further use is required.

CHAPTER XXXI.

SURGERY OF THE CHEST.

Contusions of the Chest.—Contusions of the chest unaccompanied by wounds of the thoracic viscera are usually not serious injuries. The most prominent symptom is painful respiration, and there may develop later ecchymosis from injury of the blood-vessels. It is probable that many cases of severe contusion of the chest have associated with them fracture of the ribs, which is often a more difficult injury to diagnose than would be supposed, from the fact that displacement of the fragments is prevented by the attachment of the intercostal muscles. The pectoral muscles may be partially torn from their insertions and a hæmatoma may be present.

Treatment.—The treatment of contusions of the chest consists in preventing motion upon the side of the injury by the application of strips of adhesive plaster. These should be applied as for cases of fracture of the ribs. Abscess may result from contusion of the soft parts or from the breaking down of a hæmatoma, and when present should be promptly opened and drained, with full aseptic precautions.

Contusion of the Chest with Rupture of the Thoracic Viscera.—Laceration of the lung without fracture of the ribs is a rare accident, which may result from the chest being squeezed between heavy bodies or from the passage of the wheels of wagons over it. Although the injury may occur in adults, it is most commonly observed in children, in whom the elasticity of the ribs saves them from fracture. The symptoms of this injury are shock, dyspnœa, hæmoptysis, pneumothorax, subcutaneous emphysema, and dulness on percussion if there has been free hemorrhage. If the patient survives for a few days, pleurisy will be present, and a purulent collection may also develop in the chest at a later period. The prognosis in this injury is always grave, the majority of patients dying within a few days. We have recently had under our observation three cases of contusion of the chest with rupture of the lung, all in children; two of them died within five days, the third recovered after a protracted illness.

Treatment.—In these cases the condition of shock, which is usually very marked, should be treated by the application of external warmth, and the use of cardiac stimulants. If, after reaction has occurred, the respiratory movements are painful, the chest should be strapped and opium administered freely, and, if there is evidence of hemorrhage, ergot should also be employed. The patient may develop pleurisy, and may have later a purulent collection in the pleural cavity, both of which conditions call for appropriate treatment.

Concussion of the Chest.—In addition to the previously described injury, there occasionally occurs as the result of force applied to the chest

a condition which has been described as concussion of the lung, or *commotio thoracica*, a condition analogous to concussion of the brain, in which there is serious functional derangement without organic lesion. The symptoms of this injury are collapse, great dyspnœa, and diminished respiratory murmur. These symptoms may disappear in a few hours and leave no trace of serious injury of the lung. Death, on the other hand, may occur soon after the reception of the injury, and post-mortem examination of such cases has failed to reveal any distinct lesion, the fatal result being probably due to disturbance of the cardiac ganglia and sympathetic plexus.

Treatment.—The treatment consists in lowering the head, administering cardiac stimulants, ammonia, alcohol, or strychnine, and the employment of artificial respiration, preferably by Laborde's method.

WOUNDS OF THE CHEST.

Wounds of the chest may be non-penetrating or penetrating.

Non-Penetrating Wounds of the Chest.—Wounds involving this region may be incised or lacerated or gunshot; they may be slight or extensive, involving the skin and cellular tissue only, or penetrating the deep fascia and the muscles. They may be attended with free hemorrhage, particularly if the intercostal or the internal mammary arteries have been injured. In examining these wounds the surgeon should be careful that he does not convert the wound into a penetrating one.

Treatment.—In dressing non-penetrating wounds of the chest the surgeon should be careful to sterilize the wound and keep it aseptic, for septic wounds of the chest are not infrequently followed by septic infection of the intrathoracic viscera. Incised wounds of the chest should be approximated by deep sutures, passed to the depth of the wound, or the muscles and deep fascia may be united by buried sutures, and the skin and superficial fascia approximated by a separate layer of sutures. In lacerated wounds a few sutures may be introduced to hold the parts in place, but if they cause any tension they should not be used. The wounds should be dressed with an antiseptic or sterilized gauze dressing. Healing in these cases is usually slow, on account of the constant motion of the parts in the movements of respiration, but it may be facilitated by the application of strips of adhesive plaster, limiting the motion of the chest on the injured side.

Penetrating Wounds of the Chest.—These may consist of small or extensive punctured, incised, lacerated, or gunshot wounds with or without injury to the thoracic viscera. The principal dangers in penetrating wounds of the chest arise from hemorrhage, if the intercostal or internal mammary arteries, the heart or great vessels, or the lung have been injured, and from septic infection, for it is almost impossible to disinfect the pleural cavity if infective material has once been introduced through the wound.

Penetrating Wounds of the Chest without Injury of the Viscera.—The chest-wall and costal pleura may be penetrated in incised wounds and the viscera may escape injury. The symptoms in such an injury will depend somewhat upon the extent of the wound. Air may be drawn in and pass out of the wound with the movements of respiration

(*traumatopnœa*). Emphysema of the cellular tissue in the region of the wound is also likely to be present. If the wound is extensive, the lung upon the side of the injury may collapse. Hernia of the lung may be observed. The *treatment* of these cases consists in controlling the bleeding and in sterilizing and closing the external wound and applying over it an antiseptic dressing.

Penetrating Wounds of the Chest with Injury of the Viscera.—Penetrating wounds involving the viscera, either punctured, incised, lacerated, or gunshot, are always most serious injuries. When the lung has been injured, the patient expectorates blood or bloody mucus; if the wound in the chest-wall be of considerable size, air mixed with blood may escape from the wound (*traumatopnœa*); the lung may also be collapsed, in which case dyspnœa will be marked and pneumothorax can be clearly demonstrated. Collapse of the lung occurs from air passing into the pleura with each inspiration, and when there is a wound of the lung from air passing from it with each expiration, so that it rapidly accumulates in the pleural cavity and the lung collapses. Emphysema of the tissues surrounding the wound may also be present. Prolapse of the lung may be observed in this class of wounds, and is most apt to occur in extensive wounds of the pleural sac; the protrusion taking place during expiration or a forced expiratory effort, owing to the fact that during expiration the air in the lung is under pressure, and when the support of the chest-wall is removed a part of the lung may yield to the pressure of the contained air and be forced through the wound.

Free bleeding from the external wound usually indicates an injury of the intercostal or internal mammary arteries or of the great vessels. Hemorrhage is probably one of the earliest and most fatal complications of these wounds, and, as previously stated, may arise from injury to the heart, the great vessels, or the intercostal or internal mammary arteries, or from wounds of the azygos veins. We have seen a stab wound of the chest inflicted by a small knife cause death by hemorrhage from the latter veins. We have had recently under our care a young man who had a pick driven into the right side of his chest, producing a lacerated penetrating wound about two and a half inches in length, which separated two ribs from their costal cartilages and also lacerated the lung. In this case there were marked dyspnœa, expectoration of bloody, frothy mucus, escape of air and blood from the external wound, and collapse of the right lung, and the heart and pericardium were displaced to the right side so that they could be seen and felt at the bottom of the wound. This patient, although extremely ill for a few days, finally recovered.

Treatment.—The treatment of penetrating wounds of the chest with wounds of the viscera will depend upon the nature of the wound and the extent of injury of the viscera. If hemorrhage be present, this should receive the first attention; if from the position of the wound it is probable that the bleeding arises from the intercostal or internal mammary arteries, the wound should be enlarged and the tissues ligated *en masse*, or the vessels sought for and ligatured. Difficulty may be experienced in exposing an intercostal artery, in which case a portion of the rib may be excised, or a ligature may be carried around the rib, by which procedure the vessel may

sometimes be secured. If it is found that the bleeding arises from a wound of the heart or of the great vessels, it is not probable that surgical interference can avert the fatal issue. If the bleeding has been arrested before the surgeon sees the case, and the cavity of the chest is found partially filled with blood-clot, it is wiser not to turn out the blood-clot and search for the source of the bleeding, but to close the wound and trust to the absorption and organization of the blood-clot; or, later, if the clot breaks down the resulting fluid may be removed by aspiration or incision. If hemorrhage is not a prominent symptom, the external wound should be closed with sutures, a dressing of sterilized or antiseptic gauze applied, and the respiratory movements of the chest upon the injured side limited by the application of adhesive straps. Extensive exploration of the wound in such cases is injudicious; it is much better after cleansing the external wound to apply an antiseptic dressing and depend upon aseptic occlusion. If hernia of the lung exists, which is rare as a primary complication of penetrating wounds, and the vitality of the protruding portion of the viscus is unimpaired, this should be carefully sterilized and returned within the chest; if, however, the protruding portion of the lung has been lacerated or incised, and its vitality has been impaired, it should be ligated as close to the ribs as possible, and the portion in advance of the ligature excised, the stump being returned within the chest, or secured in the wound by a few sutures, and the external portion of the wound closed by sutures and covered with an aseptic or antiseptic dressing. Hernia of the lung occurring after the external wound has healed should be treated by the application of a compress held in position by a belt.

Emphysema and Pneumothorax.—These conditions may result from penetrating wounds of the chest; the latter, if excessive, may cause marked dyspnœa, and be recognized by hyper-resonance over the seat of injury, with absence of respiratory murmur, amphoric breathing, and occasionally metallic tinkling. *Emphysema*, which is usually manifested by swelling of the tissues in the region of the wound, may be recognized by the elastic character of the swelling, and by the fact that it crepitates upon pressure. Emphysema may be limited to the region of the wound, or may extend widely through the tissues, even involving the whole body, giving the patient a bloated appearance. A form of emphysema occurring after punctured wounds, particularly of the anterior region of the chest, known as *mediastinal emphysema*, caused by air passing back under the pleura to the connective tissue at the root of the lung, may give rise to marked dyspnœa and embarrassment of the circulation and lead to a fatal termination. Pneumothorax may be avoided, when there is fear of causing it during operations, by filling the wound with normal salt solution or packing it with wet sponges or gauze. Pneumothorax, if extensive and involving both sides of the chest, may produce so much dyspnœa that life will be threatened. We have seen unilateral pneumothorax result in death, the other lung being crippled by adhesions. In this condition aspiration of the air from the cavity may be employed, or, better, the pleural sac may be filled with salt solution, the wound tightly closed, and subsequently the fluid aspirated. Emphysema usually requires no surgical treatment, the air

ceasing to spread and disappearing as soon as the wound in the chest-wall is closed.

Hydrothorax and Empyema.—These affections may exist as complications of penetrating wounds of the chest, and their presence may be diagnosed by the time of development of the symptoms of dulness upon percussion and the absence or feebleness of vocal and respiratory sounds over the seat of injury. The treatment of these conditions will be considered under Operations upon the Chest.

The *constitutional* treatment of cases of penetrating wounds of the chest consists in the use of opium, the patient being kept absolutely at rest. If pneumonia or pleurisy develops it should be treated as if arising independently of traumatism.

Gunshot Wounds of the Chest.—These injuries may be inflicted by balls, bullets, or small shot; if inflicted by the latter at close range, extensive laceration of the chest wall and viscera may result. Gunshot wounds of the chest may be penetrating or non-penetrating; the former are always serious injuries, the records of military surgery showing a heavy mortality after them. Conner states that from one-half to one-third of those killed outright in action have been found to have died from gunshot wounds of the chest.

Non-Penetrating Gunshot Wounds.—These injuries are not usually serious unless they occur in the axillary or the subclavicular region, involving injuries of the vessels, in which case they are very grave injuries and are often quickly fatal. Balls not infrequently strike a rib and are deflected, passing around the rib to the spine, and either escape through a wound of exit or remain embedded in the tissues.

Treatment.—If in these injuries only a wound of entrance exists, and the ball cannot be easily located, it is unwise to make extensive explorations with a probe to locate the ball, or free incisions to remove it, as by so doing the wound may be converted into a penetrating one. It is better to disinfect the wound and apply an antiseptic dressing, repair usually taking place promptly, and the ball, if it causes trouble, may be located and removed at a later period. If the missile has passed through the soft parts and escaped, the wound should be treated as a non-penetrating wound produced by other causes.

Penetrating Gunshot Wounds.—These wounds, as previously stated, are most serious injuries; the missile may lodge in the viscera or may injure the heart or the great vessels. The latter injury is almost always fatal, but penetrating wounds involving the lung are not so serious, and a fair proportion of such cases recovers. The modern ball used in warfare is apt to perforate the chest and escape, and is not likely to lodge in the viscera. Penetrating pistol-ball wounds of the chest occurring in civil practice, unless the heart or the great vessels be involved, although grave injuries, are not often fatal, the majority of cases doing well under treatment.

Treatment.—If the ball has penetrated the chest and escaped, or has penetrated the chest and remains embedded in the viscera, no information can be obtained by probing: hence this should be avoided, and attempts to locate the ball and remove it by operation should not be undertaken. If,

however, the ball has penetrated both chest-walls and the lung, and is arrested under the skin and can be located, it should be removed, and the wounds sterilized and dressed antiseptically. In penetrating gunshot wounds caused by small shot at short range, or by fragments of wood or stone from blasting accidents or explosions, when a portion of the chest-wall is torn away, exposing the lung or even lacerating or tearing away a portion, a most serious injury is presented. Such cases should be treated by first disinfecting the wound as far as possible, removing foreign bodies which may be present, packing the wound loosely with sterilized gauze, and covering the region with a large gauze dressing. Under this method of treatment it is not unusual to have recovery follow, even when there has been extensive destruction of both the chest-wall and the lung.

Wounds of the Mediastinum.—The mediastinal space is occupied by the heart surrounded by its pericardium, the great vessels, the descending aorta, the œsophagus, and the pneumogastric nerves.

Wounds of the Heart and Pericardium.—Rupture of the heart and pericardium may occur as the result of contusion of the chest without fracture of the ribs. Traumatic ruptures of the heart and pericardium are invariably followed by a fatal result, death usually occurring promptly, but in a few cases life has been prolonged for a few hours. The heart, pericardium, and great vessels may be injured by incised, punctured, lacerated, and gunshot wounds, and, although the prognosis in these wounds is always grave, death in many cases taking place very promptly, in a number of instances recovery has followed. Death may result from shock and pulmonary anæmia, from pressure upon the heart of the blood in the pericardium, or from direct injury of the cardiac muscle preventing its contraction.

Symptoms.—The symptoms of wounds of the heart are sharp pain, cardiac syncope, feebleness of heart-sounds, dulness upon percussion, and enlargement of the normal area of dulness, caused by hemorrhage into the pericardium.

Treatment.—The patient's head should be lowered, to prevent syncope from cerebral anæmia, external warmth should be applied, and opium given to relieve pain, and, if reaction occurs, cardiac sedatives should be administered.

Foreign bodies may penetrate and become lodged in the heart, and their removal should be attempted if their position can be located and their presence causes marked disturbance. Patients have recovered with foreign bodies remaining in the organ, and a few cases have been recorded of the successful removal of foreign bodies from the heart. Wounds of the great vessels at the base of the heart and of the descending aorta are usually promptly fatal and are beyond the reach of surgical treatment.

Wounds of the Diaphragm.—The position of the diaphragm varies with the respiratory movements, and may be markedly changed by distention of the abdominal contents or cavity, or by thoracic tumors or pleuritic effusions: hence it may be injured by wounds out of its ordinary situation.

Rupture of the diaphragm may result from contusion of the chest, as well as from a similar injury to the abdomen, and is more common on the left than on the right side, the liver upon the right side possibly protecting it to

a certain extent. Rupture of the diaphragm is a serious injury, and may be associated with injury of the thoracic or abdominal viscera, or with hernia of the intestines or stomach through the rent: strangulation of the latter organs may lead to a fatal result.

Wounds of the diaphragm are generally associated with penetrating wounds of the chest or abdomen; the sharp extremity of a fractured rib may also cause a wound of the diaphragm. If the wound is small and hernia does not occur, and if the adjacent viscera are not severely injured, the prognosis as regards recovery is good. The symptoms of rupture or of wounds of the diaphragm are a rapid and irregular pulse, disturbed respiratory action (diaphragmatic action being diminished and the action of the accessory muscles of respiration being increased), pain, dyspnœa, coughing, and in some cases hiccough. If a hernia exists there may be a peculiar resonance at the seat of injury, and auscultation may disclose the presence of fluid in the intestines or the stomach as they rest in the thoracic cavity.

Treatment.—Small wounds of the diaphragm in which no hernia has occurred probably heal promptly, and it is often impossible to diagnose these lesions. In a case, however, of contusion or wound of the chest or abdomen where the presence of a rupture or wound of the diaphragm with hernia of either the stomach or the intestines can be made out, it is justifiable to open the abdomen and search for the wound in the diaphragm, reduce the prolapsed viscus, and close the rent with sutures. A few successful cases in which this procedure was adopted have been reported.

Congenital Defects of the Diaphragm.—A congenital defect is sometimes observed in the diaphragm; a considerable portion may be wanting, or there may be a congenital fissure which permits some of the abdominal organs to escape into the thoracic cavity. This condition is not likely to be recognized during life unless strangulation of the hernia occurs, in which event a laparotomy should be performed and an attempt made to reduce the hernia and close the fissure.

Mediastinal Abscess.—Abscess of the mediastinum may result from traumatism, such as contusions, fractures, gunshot wounds, or punctured wounds of the anterior region of the chest. This form of abscess may have its origin in abscess of the neck, in which case the pus burrows down behind the deep cervical fascia, or may result from suppuration of tubercular mediastinal glands, or from caries or necrosis of the sternum. The symptoms of mediastinal abscess are fever, deep-seated pain which is increased upon coughing or swallowing, dyspnœa, œdema of the tissues over the sternum, and dilatation of the superficial veins. The abscess may point at the lateral aspect of the sternum or at the ensiform cartilage.

Treatment.—If there is evidence of pointing at the sides of the sternum or at the ensiform cartilage, an incision should be made, the pus evacuated, and the cavity drained. If, however, there is no evidence of pointing in these situations, the sternum should be trephined and the abscess opened and drained.

Tumors of the Mediastinum.—Tumors of the mediastinum may be benign, such as lipoma, fibroma, dermoid or hydatid cysts, or enlargements of the thymus or mediastinal glands. Aneurism may also exist in this

region. Malignant growths of the mediastinum are either sarcomata, carcinomata, or lymphomata. Sarcoma is the form of disease most commonly met with, and usually involves the anterior mediastinum. Carcinoma of the mediastinum occurs next in point of frequency. These growths may occur either as primary or as secondary affections.

Symptoms.—The principal symptoms of mediastinal tumor are pain, dyspnœa, cough, œdema of the neck from obstruction of the venous return, dilated veins, displacement of the heart, and in some cases disturbance of function of the pneumogastric nerves, if they are included in the growth.

Treatment.—The removal of mediastinal tumors is an operation attended with great danger, and can be accomplished with safety to the patient in rare cases only. The operation necessitates the removal of a portion of the sternum and ribs, and when the tumor is exposed it is often found that it is so firmly attached to important structures in the thorax that its removal cannot be safely accomplished.

PLEURITIC EFFUSIONS.

Collections of fluid in the pleural cavity may occur from injury of the chest, or from acute or chronic inflammatory affections of the pleura or lungs; pleural effusions may also result from tumors of the pleura, causing obstruction of the venous circulation. Acute pleural effusions are serous unless they result from injury to the chest or thoracic viscera, in which case they often contain a certain amount of blood. Chronic pleural effusions are usually purulent, and may arise from the infection of acute effusions by staphylococci, streptococci, or diplococci, or may be caused by tubercular pleurisy, and in such cases pyogenic organisms are present. Pleural effusions may form rapidly or slowly; as a rule, the effusions following acute pleurisy accumulate very rapidly, and the pleural sac is often almost filled with fluid in twenty-four or thirty-six hours. Slowly forming effusions, on the other hand, generally result from the presence of tumors or from tubercular pleurisy; in the latter case there is usually marked thickening of the pleura itself. A serous effusion may become purulent from infection by pyogenic organisms or from the bursting of an adjacent abscess into the pleural sac.

Symptoms.—The prominent symptoms of pleural effusions, whether serous or purulent, are dyspnœa, rapidity and feebleness of the pulse, elevation of the temperature, and bulging of the intercostal spaces on the affected side, as well as dulness upon percussion, most marked at the base of the chest, the line of dulness varying with the position of the patient. The patient generally rests upon the affected side. The apex beat of the heart is usually displaced to one side, according to the position and amount of the effusion; displacement of the apex beat to the right side is always more marked than displacement to the left. Respiratory murmur is weak or absent over the portion of the chest occupied by the effusion, and vocal fremitus is absent, while over the lung compressed by the effusion bronchial breathing may be heard. Although in most cases the presence of effusion can be clearly made out by the physical signs, yet it is often well to verify the diagnosis by the use of the aspirator or exploring trocar. These instru-

ments should be carefully sterilized before being used, as a serous effusion may easily be converted into a purulent one by neglect of this precaution.

Treatment.—Small acute pleural effusion is often absorbed, but if the effusion be extensive, as soon as it interferes with the function of respiration its removal should be accomplished by surgical means. A diseased pleura cannot be depended upon to absorb a large amount of pleural effusion; the long-continued pressure of such an effusion upon the lung may seriously interfere with its subsequent expansion, and reaccumulation of the effusion is more apt to occur in cases where the operation is delayed than in cases in which the effusion is promptly removed.

Purulent Pleural Effusion.—Empyema.—The term empyema is generally used to indicate a collection of pus in the pleural cavity, although it may also be used to designate a collection of pus in any cavity of the body. Purulent pleural effusion may result from an acute serous effusion which has been contaminated by pyogenic organisms, or from the infection of blood or serum in the pleural cavity after penetrating wounds of the chest or lung. By far the greater number of cases of purulent pleural effusion, however, result from tubercular pleurisy, which may develop at the termination of an acute process, such as pleurisy, pneumonia, or pleuro-pneumonia, and we may have in such cases in addition to the tubercle bacilli the diplococcus pneumoniæ as well as streptococci and staphylococci. In recent purulent pleural effusion the pleura is not much thickened, but in cases of some duration the pleura is always thickened, and may be from half an inch to an inch in thickness.

A small purulent pleural effusion may in the course of time largely disappear, the fluid portions being absorbed, and the more consistent portions undergoing caseation and absorption or becoming encysted. The purulent matter in the chest may penetrate the lung and enter a bronchial tube and escape by the mouth, or may burrow through the pleura and intercostal muscles and point upon the surface of the chest, or may perforate the diaphragm, giving rise to a subdiaphragmatic abscess, or may pass into the abdomen or behind or in front of the peritoneum, giving rise to an extraperitoneal abscess.

Symptoms.—The physical signs of purulent pleural effusion are the same as those of serous pleural effusion, with the addition that in the former there are symptoms which indicate the presence of pus, chills, sweating, irregular temperature, and emaciation.

Treatment.—When it is evident that a pleural effusion is purulent, in view of the very slight chance of its undergoing absorption, as well as of the danger that its presence causes the patient, it should be promptly removed, either by aspiration, which only in exceptional cases is followed by a cure, or by incision and drainage, which should be promptly resorted to and is most likely to be followed by a satisfactory result.

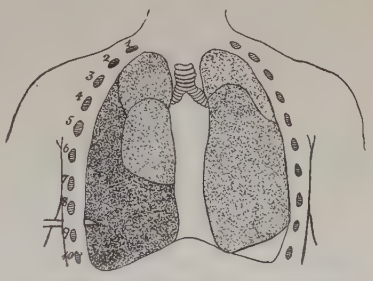
OPERATIONS UPON THE CHEST AND ITS CONTENTS.

Paracentesis Thoracis.—This operation consists in perforating the walls of the chest with a trocar and canula to remove an effusion from the pleural cavity. The most convenient instrument for this purpose is the

aspirator. If an aspirator is not at hand, a trocar and canula may be used, and after the withdrawal of the trocar one end of a rubber tube may be fastened to the end of the canula, and the other placed in a basin of water to prevent the entrance of air into the chest, or a puncture may be made with a narrow-bladed knife, and the puncture kept open by the introduction of a grooved director. Whichever form of instrument be used, it is essential that it be thoroughly sterilized before being introduced in the pleural cavity.

In performing paracentesis thoracis it is not usually necessary to give an anæsthetic, as the operation is not painful; but, if desired, local anæsthesia may be produced by ice applied to the surface, by a spray of rhigolene, or by the subcutaneous injection of cocaine. The patient should be in a semi-recumbent posture, and the skin surrounding the seat of the proposed puncture should be carefully sterilized. The part usually selected is the mid-axillary line, between the seventh and eighth or the eighth and ninth ribs. (Fig. 752.) The skin is drawn upward or downward with the finger, and the needle is introduced with a quick thrust; when it has penetrated the pleura the trocar is removed and the fluid is allowed to escape into the vacuum-bottle. If the patient presents no unfavorable symptoms, as much fluid as possible should be removed, but if he shows symptoms of syncope after a considerable quantity of fluid has been removed, the head should be lowered and the needle withdrawn. If the patient coughs, and blood escapes from the canula, showing that the lung has been punctured, the instrument should be withdrawn. When it is removed the small puncture should be closed with gauze and iodoform collodion. In many cases of simple serous effusion one or two tappings will effect a cure, and in purulent effusion, especially in children, a cure may result from one or more tappings. As a rule, however, in purulent effusion aspiration gives only temporary relief, and a cure results only after an incision has been made and thorough drainage has been established.

Fig. 752.



A, position at which to open the pleural cavity. (After Dennis.)

Thoracotomy.—Pus may be removed from the pleura by a simple incision between the ribs, from an inch to one and a half inches in length, which should be made in a dependent portion of the chest and in the mid-axillary line. Simple incision without the introduction of a drainage-tube is not often practised.

The most satisfactory method of draining purulent pleural effusions is as follows. The chest upon the side of the operation should be shaved, especially the axillary region, and the skin should be carefully sterilized; after mapping out the area of dulness, an incision about one and a half inches in length should be made through the tissues between the sixth and seventh ribs in the mid-axillary line; the tissues being carefully divided until the pleura is exposed, this should be opened with a knife or a director, when

purulent matter will escape from the opening. A stout flexible metallic probe with an eye in its point is bent and passed into the wound, and is made to project in the intercostal space between the eighth and ninth ribs. This is cut down upon, and, when exposed, is pushed out of the lower wound; it is then attached to a large-sized rubber drainage-tube and withdrawn, and as this is done the tube is carried through the pleural cavity. If it is found that the ribs are so close together that the tube is compressed sufficiently to interfere with drainage, a small portion of the upper surface of the rib may be removed with gouge forceps to make room for the tube. The ends of the tube are then transfixed with safety-pins and cut off flush with the skin. It is often well to introduce also a short drainage-tube several inches in length into the lower wound, to secure additional drainage.

As a rule, irrigation of the pleural cavity is to be avoided unless the pus is offensive, when the cavity may be irrigated with warm sterilized water, or a solution of tincture of iodine f℥i to sterilized water one pint, or a 1 to 8000 bichloride solution. The skin surrounding the opening of the drainage-tube should be washed with bichloride solution, and the tubes should be covered with a piece of protective or rubber tissue, which often acts as a valve over the mouth of the tubes, allowing the discharge to escape, but preventing the entrance of air; a copious dressing of sterilized or bichloride gauze and cotton is placed over the opening of the tube and held in position by a bandage. The dressings should be renewed as soon as they become soaked, usually within twelve or twenty-four hours, and subsequent dressings will be required less frequently. At the end of a week or ten days, if the amount of discharge is diminishing, the tubes may be shortened, or one may be removed; and at the end of two or three weeks, if there is only a little thin discharge from the remaining tube, it may be removed, and the wound then usually closes in a few days. If this method of incision and drainage is employed, and the case is not one of very long standing with great thickening of the pleura, the lung expands, and a satisfactory result is obtained. That simple drainage in many cases is not followed by a cure is due to the fact that a very small tube is introduced and free drainage is not established. However, in long-standing cases, or cases in which a spontaneous opening has occurred at some point of the chest, and there is a sinus with great thickening of the pleura which prevents free exposure of the cavity, a more radical operation has to be resorted to—that is, the excision of a portion of one or more ribs. In the treatment of the empyemas of children, owing to the elasticity of the chest-walls, we have seldom had to resort to excision of the ribs, a satisfactory result usually following incision and drainage. In these cases there is often a certain amount of deformity of the chest by the falling in of the wall towards the lung to obliterate the pleural cavity.

Thoracoplasty.—Estlander's Operation.—This operation consists in exposing and removing several inches of several contiguous ribs, so that the chest-walls can fall inward and come in contact with the pulmonary pleura, thus obliterating the cavity. This procedure has proved a most valuable one in cases of long-standing empyema which have ruptured spontaneously

at some point of the chest-wall and have resulted in a thoracic fistula, also in cases in which the lung is so bound down by adhesions that incision and drainage have failed to bring about a cure.

Operation.—An oval flap six inches in length and four inches in breadth, with its base near the mid-axillary line, is dissected up from the chest so as to expose three or four ribs, or an incision six inches in length may be made over the fifth, sixth, seventh, and eighth ribs in the mid-axillary line, and two rectangular flaps may be dissected up, one backward and one forward, from this incision, so as to expose from four to six inches of two or three contiguous ribs. The ribs are next divided at the extremities of these incisions with a narrow saw or bone pliers, and removed. Hemorrhage from the intercostal arteries is not usually troublesome, but if they bleed they can be secured by ligatures. The costal pleura should next be freely opened to the length of the incision, making an opening in the chest as large as the removal of bone will permit. The number and extent of the ribs to be excised will depend upon the size of the cavity exposed. The exposed cavity should be irrigated with sterilized water, the surfaces of the costal and the pulmonary pleura curetted, and a few strips of gauze loosely packed into the cavity. The flaps should then be laid over the cavity, but need not be secured by sutures. A large sterilized or antiseptic gauze dressing should be applied and held in place by a bandage. As healing progresses, the soft parts are drawn inward and become attached to the pulmonary pleura, and the cavity is obliterated.

Fig. 753.

Result of Schede's operation on right side of chest.

Schede, in cases of thoracic fistula in which there is great thickening of the pleura, recommends a still more radical operation, which consists in exposing and excising a large portion of the chest-wall over the cavity. In this operation an incision is made, and a large oval flap of skin and muscles is dissected up, exposing a number of ribs; the chest-wall over the cavity, composed of the exposed ribs, intercostal muscles, and costal pleura, is then cut away with strong bone shears, and, after curetting and washing out the cavity, the skin-flap is applied to the pulmonary pleura. This operation is attended with considerable danger from shock and hemorrhage, and produces great deformity of the chest at the seat of operation: it should therefore be employed only when a less heroic procedure has failed to bring about a cure. (Fig. 753.)

OPERATIONS UPON THE LUNGS.

Pneumonotomy.—This operation, which consists in making an incision into the tissue of the lung, may be employed for the drainage of abscesses or cysts, in the treatment of gangrene of the lung, for the removal

of foreign bodies, in cases of bronchiectasis from foreign bodies, and for the exposure and treatment of tubercular cavities.

The most favorable cases for pneumonotomy are those of abscess or gangrene of the lung, in which the pulmonary tissue overlying and surrounding the abscess or the gangrenous area is adherent to the costal pleura. When the operation is performed for the relief of bronchiectasis, following the lodgement of a foreign body, the cavity may be opened and drained and the foreign body removed. Bronchiectasis if it involves one tube only is much more favorable for operation than when a number of tubes are affected. The operation of pneumonotomy in the treatment of tuberculous cavities should, according to Godlee, be restricted to cases in which there is a single cavity in a favorable location and the patient is being worn out by the harassing cough.

Operation.—The patient being anæsthetized, the position of the cavity should be accurately located, and an incision two inches in length should be made at its most dependent portion through an intercostal space; when the lung is exposed, if this is not adherent to the chest-wall, it may be fixed to the chest by the application of a few sutures, and attempts to open the cavity should be postponed for a few days until adhesions shall have formed. If the lung is adherent to the chest-wall, an exploring trocar may be passed through the lung-tissue to verify the diagnosis. If the lung becomes collapsed, dyspnœa may be so marked that artificial respiration will have to be resorted to, or forced respiration may be employed through a tracheal canula. It may also be necessary to resect a portion of one or two ribs to expose the cavity sufficiently. When the cavity is located, the superimposed lung-tissue may be divided with a knife, or the cavity may be opened with the knife of Paquelin's cautery. The cavity should be explored with the finger, and if a foreign body can be located it should be removed with forceps. If gangrenous tissue is present, it should be gently removed with the curette. The cavity should then be irrigated with some non-irritating antiseptic solution, and a large drainage-tube should be introduced. The after-treatment consists in washing out the cavity and retaining the drainage-tube until expectoration, and discharge from the wound, have entirely ceased.

Pneumonectomy.—This operation consists in the excision of a portion of the lung, and may be required for the removal of tumors of the lung, or of tumors of the chest which have involved the lung, or in the treatment of recent or old irreducible herniæ of the lung following injuries. It has also been employed for the removal of tuberculous portions of the lung. Experimental research has shown that in animals a considerable portion of the lung may be removed with comparative safety.

The steps of the operation are similar to those for pneumonotomy. The lung-tissue should be divided with a knife, or with a cautery knife to avoid hemorrhage. The results of this operation in human beings have not been sufficiently encouraging to justify its employment save in exceptional cases.

Intrathoracic Tumors.—These growths may spring from the walls of the chest or from the thoracic viscera. Those arising from the thoracic viscera are not cases for surgical treatment. Tumors springing from the chest-wall are usually carcinomata, and if not too intimately connected

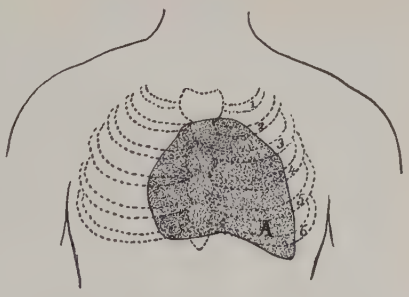
with the thoracic viscera can often be removed with safety; in some cases they may be removed subperiosteally; in others it is necessary to open the pleural cavity. The operation for the removal of intrathoracic tumors is always attended with great risk, and the surgeon should be guided in his opinion as to the advisability of their removal by the size of the growth and the presence of healthy skin over the tumor, for if the wound cannot be covered by skin the operation should not be attempted. The attachment of the growth to the viscera is also a condition which should decide the surgeon for or against operation. In operating upon these growths a free incision should be made, and it will often be found necessary to divide several ribs and remove portions of them with the growth.

In the removal of substernal cysts and tumors excision of a portion of the sternum is often required.

For the removal of posterior mediastinal tumors, for the relief of pressure from enlarged glands, or for the removal of foreign bodies from the œsophagus or bronchi, J. D. Bryant has suggested opening the thorax from behind by resecting the ribs from a line near their angle to the inner side of the scapula.

Paracentesis Pericardii.—This operation may be required for the relief of distention of the sac from pericardial effusion following injuries or resulting from acute or chronic pericarditis. The heart extends from the third to the sixth costal cartilage and from half an inch to the right of the right border of the sternum to a point half an inch to the right of the left nipple. The symptoms of pericardial effusion are pushing upward or loss of the apex beat, dyspnœa, præcordial oppression, feeble, irregular pulse, difficulty in deglutition, dilatation of the cervical veins, increased area of cardiac dulness, which is triangular in shape, and muffling of the heart-sounds. These symptoms may arise from a serous or purulent effusion in the pericardium.

FIG. 754.



A, position at which to open the pericardium. (After Dennis.)

Operation.—The removal of serous effusion from the pericardium is usually accomplished by introducing the needle of the aspirator into the fifth intercostal space at a point two inches to the left of the left border of the sternum, external to the internal mammary artery. (Fig. 754.) The needle should be thrust directly through the chest wall, and the fluid allowed to escape very slowly. If it is found that the effusion is purulent, although temporary relief may be afforded by aspiration, it will subsequently be necessary to incise and drain the pericardium. An incision should be made at the same point as for tapping the pericardium, a soft rubber or gauze drain introduced, and a copious antiseptic dressing placed over the wound.

CHAPTER XXXII.

SURGERY OF THE BACK.

VERTEBRÆ AND SPINAL CORD.

INJURIES OF THE BACK.

Incised and contused wounds of the back do not differ from those in other situations, except that a very severe contusion may affect the spinal cord or the kidneys. Sprains of the muscles of the back can be distinguished from the deeper sprains involving the spinal column by the lesser severity of the symptoms. The sprained muscle is generally tender to the touch, and sometimes is more or less contracted, although more frequently the surrounding muscles are in a state of spasm in order to avoid any motion of the injured one. Rest, massage, and counter-irritation are the best methods of treatment. A broad strapping of plaster similar to that for fracture of the ribs is also useful.

FRACTURE AND DISLOCATION OF THE SPINE.

In the vertebral column fracture and dislocation are almost invariably combined, the interlocking of the bony processes making it difficult for a dislocation to occur without fracture, and the dislocation is usually the more important part of the injury. These injuries of the spine are rarely met with in children. The accident may occur in any part of the column, but is most frequent in the cervical and dorsal regions, and especially affects the fifth and sixth cervical, the second dorsal, and the first lumbar vertebræ. The fracture most frequently consists in a crushing of the bodies of the vertebræ or fracture of the articular processes. Fracture of the spinous processes or the laminæ alone is very rare. The displacement in fracture-dislocations may be forward, backward, or rotary. The injuries are caused by falls upon the head or on the buttocks, or a fall across a beam so that the spine is bent violently backward.

Symptoms.—As in fractures of the skull the most important symptoms are due to the brain lesion, so in these injuries the chief symptoms depend on the damage inflicted on the spinal cord and the nerve-roots. The **local symptoms** found in the spine itself are: (1) **Deformity,** which may show itself by the backward projection of the spines if the bodies are crushed, and by a lateral displacement of the tips of the spines if the injury has been upon one side or if a rotary dislocation exists. The deformity may not be evident until the patient is able to stand. (2) **Altered Mobility.** The mobility of the spine may be impaired, and the rigidity may be associated with curvature or rotation. Abnormal mobility at the point of the

fracture is very seldom found, although in some cases motion may be felt in the fragments. (3) **Pain and Tenderness.** Pain may or may not be present, and it is often due rather to pressure upon or injury of the nerves than to the injury of the bones. Local tenderness is a very common symptom, and is useful in locating the exact site of the lesion. (4) **Crepitation** can seldom be obtained with the slight amount of motion which it is safe to make in the examination.

Spinal Cord Symptoms.—The canal containing the cord is so narrow that even a slight displacement of the bones causes pressure upon that organ, the amount of injury to the latter depending upon the degree of the pressure. The cord may be crushed and entirely divided or it may be slightly compressed by the displaced bones. In the first case a complete paralysis results, and its extent depends upon the situation of the injury to the cord, varying from a complete paralysis from the neck downward to a paralysis of the lower extremities only. In the more localized and partial injuries, and especially if the nerve-roots only are compressed, the paralysis may be confined to a single group of muscles or to a single extremity. The injury to the cord is frequently out of proportion to the displacement of the bone, as the latter partly returns to its proper position, and the compression is partially relieved in at least two-thirds of the cases. Besides actual destruction or compression of the cord by the displaced bone, the injury may cause the formation of a hæmatoma in the canal or in the substance of the cord which will cause symptoms of gradually increasing pressure. In any case of fracture or dislocation of the spine, besides the immediate injury inflicted on the spinal cord a secondary descending myelitis with degeneration is quite common. In injuries of the upper four or five cervical vertebræ, although the cord is less likely to be injured, because that is the widest part of the canal, there is great danger of sudden death from injury to the phrenic nerve. Paralysis of the intercostal muscles may be produced by injury at this point or even in the dorsal region. Paralysis of the bladder and of the intestine may be produced by injury in any part of the cord. Priapism is a common symptom of injury in the cervical region. The reflexes may be present or they may be lost. Pressure sores form over the sacrum and over any of the bony points on the paralyzed limbs, and even on the penis where it rests on the edge of a vessel in constant use in cases with dribbling of urine. The pressure sores may become very extensive, covering the entire back, and add considerably to the exhaustion of the patient.

In simple **dislocation of the spine** there is most frequently a forward displacement of the upper vertebra at the point of injury. This is called an anterior bilateral dislocation when it affects both lateral articulations, and when it is confined to one side it is called a rotary dislocation. The bilateral form is the more common and also the more dangerous. Backward dislocation is rare, except that in rotary dislocations a partial backward displacement is found in the joint of the opposite side. It is sometimes possible to distinguish dislocation from fracture by the greater rigidity and the frequent occurrence of contractions of the muscles supplied by nerves above the point of injury in the dislocation. Reduction of the deformity is also

more difficult than in the case of fracture, but the cord is less likely to be injured. The deformity and rigidity of a dislocation are sometimes simulated by the stiffness of the spine seen in simple sprains, but in such cases the deformity is not so well marked. The prognosis as to life is naturally better in dislocation than in fracture, particularly in the rotary form. In simple dislocation the neck is most frequently affected, and the dorsal region, although seldom injured, suffers more frequently than the lumbar.

In anterior bilateral dislocations of the vertebræ the vertebra just below the joint affected will be prominent at the back, and the one above, being displaced forward, will project in front. This can be ascertained in the cervical region by inserting the finger into the pharynx where the body of the atlas lies on a level with the posterior nares. In these displacements in the neck the head is usually bent forward and fixed in this position, but occasionally it is straight, or even bent backward. In rotary dislocations the head and face are rotated towards the shoulder of the side opposite to the injury, and the head is also inclined laterally to that side. (Fig. 755.) The chin may be turned to the same side as the injury. The neck is convex on the injured side, and the muscles are tense, the tips of the spines making a convex curve in that direction. Occasionally one of the spines is felt to be displaced laterally towards the convex side, and sometimes a greater prominence is perceptible in the pharynx upon the injured side.

Fig. 755.

Unilateral dislocation of cervical vertebræ. (Dr. G. L. Walton.)

Prognosis.—In estimating the prognosis in injuries of the spinal column we must distinguish between the effect upon the column itself and that upon the nervous structures. Fractures in the cervical region are almost invariably fatal, and the large majority of the patients die within three or four days, while if recovery takes place a permanent paralysis usually remains. In the dorsal region the prognosis is better, and death is generally postponed for several weeks. In the lumbar region less than one-half of the patients die; the fatal result occurs later, and the paralysis may entirely disappear if recovery takes place. The bony deformity may be permanent, leaving a rigid spine bent or rotated at the point of injury. The prognosis of the nerve injury will depend on the extent of the lesion. If there is extensive paralysis, such as progressive paralysis of the respiratory muscles or inflammation of the bladder, the patient will probably die from its effects.

Treatment.—When a severe injury has been sustained which has probably resulted in fracture or dislocation of the spine, the greatest care and gentleness must be exercised in handling the patient, lest fatal injury be inflicted on the cord. In rare cases the patient may be able to walk and may

have no severe symptoms for days, and may then suddenly die from accidental displacement of the bones. Usually, however, he will be found lying down, often in collapse, and a stretcher, a board, or a sheet should be slipped under him, his neck and head being moved as little as possible, so that he can be transported to his bed.

These injuries may be treated by three methods. First, by the **expectant plan**, in which the patient is simply kept at rest on a water-bed, the head and body being properly supported by sand-bags or pillows on each side, or by a plaster jacket or spinal brace. In the second method some effort is made to **reduce the displacement**, which is most readily accomplished when the injury is in the cervical region, because here the bones are small and easily accessible, and strong extension with rotation or flexion of the head is often successful. The reduction should be attempted only with the full understanding of the patient that it is dangerous, for the control over the bones is so slight that a fatal injury to the cord might be produced. These manipulations should be limited to forcible extension of the parts, since attempts at flexion are more likely to increase the injury. If simple extension is insufficient for reduction, the suspension apparatus employed in applying the plaster of Paris jacket for Pott's disease may be applied and the patient suspended. Finally, there is the **operative** method. The bones being exposed by an incision along the spine, as in laminectomy, the depressed bone may be removed or elevated, or a dislocation reduced by proper manipulation under the control of the finger and the eye. If the case be seen early enough and if the injury to the cord be not too extensive, good results can undoubtedly be obtained by operations of this nature. After reduction the head and body should be encased in a plaster of Paris jacket.

In the after-treatment the principal attention must be given to the paralysis of the bladder and bowels and to the pressure sores. The regular use of the catheter must be begun, with every precaution against cystitis, which is almost certain to develop sooner or later. If cystitis occurs, irrigation of the bladder must be systematically carried out. It has been suggested by some to allow the bladder to fill up without the use of the catheter and to establish "incontinence by overflow," so as to avoid infection from instruments, but with proper nursing this should not be necessary. The bowels should be evacuated by the use of softening enemata and laxatives, and properly regulated by the diet, food being given which will produce as little fecal matter as possible. Pressure sores are to be avoided as far as may be by changing the position of the patient, by the use of small pillows, by careful washing of the back, by hardening the skin with alcohol or an ichthyol solution, and by painting the doubtful-looking spots with iodoform collodion. Even with the greatest care pressure sores are prone to develop after several weeks or months' confinement in bed.

Gunshot fractures of the spine are mainly of importance on account of the great danger of injury to the cord by the missile or by the flying fragments of bone. The injury to the bony column is usually less than in other fractures, and the treatment is carried out on general principles.

INFLAMMATIONS AND TUMORS OF THE BACK.

Cellulitis and **carbuncle** are found, but do not differ from the ordinary varieties of these affections. **Syphilitic eruptions** are also very frequent. **Bursitis** of the gluteal bursæ occurs, and less frequently the bursæ about the scapula are inflamed. They present the usual symptoms, and are treated along the lines laid down elsewhere. Both benign and malignant **tumors** occur on the back, the most frequent being sebaceous cysts and lipomata. Sarcoma is found in the deep muscles of the back, and epithelioma occurs, although very rarely, in the skin.

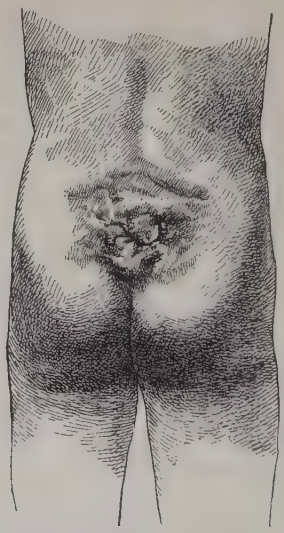
SPINA BIFIDA.

Spina bifida (Fig. 756) is a congenital tumor, originating from the spinal canal, just as the meningoceles form on the head. Owing to improper development of the spinal column, its canal is not closed posteriorly, and protrusion of the membranes, and even of some of the nervous structures, takes place through the opening in the bones, from the pressure of the cerebro-spinal fluid. This protrusion may be situated in any part of the spine, but is most common in the lumbar and sacral regions. The skin covering the sac may be normal, but it is usually thin and translucent, and may be very vascular. In some cases the sac consists only of the membranes of the cord. The communication with the spinal canal may be very narrow or may involve many vertebral arches. Nerves are frequently seen running in the

Fig. 756.

Spina bifida.

Fig. 757.



Spontaneous cure of spina bifida.

walls of the sac and returning at the lower margin to their normal course, or crossing the cavity from side to side, like tense bands. The substance of the spinal cord is occasionally expanded over the walls of the sac. The cord and nerves are involved in two-thirds of the cases, and paralysis is a fre-

quent complication. When the protrusion consists of the membranes only it is called a **meningocele,** and when the cord is also involved it is termed a **meningo-myelocele.** In some cases the sac is formed of the cord itself, the cavity being the dilated central canal of the cord: such cases have been called **syringo-myeloceles.** The word **hydrorrhachis** is also used to designate spina bifida. If the opening in the spinal canal is large, the sac sometimes swells up with strong respiratory efforts in crying or coughing, but pulsation is rare. Strong pressure on the sac sometimes increases the tension of the fontanelle, and may cause convulsions and signs of cerebral compression. These tumors tend to increase in size, the coverings becoming thinner, until finally they slough. This accident results in death, either from the loss of the cerebro-spinal fluid or by infection of the membranes and meningitis. A spontaneous cure occurs in rare instances (Fig. 757), the tumor gradually growing smaller and the coverings over the sac gradually thickening.

Spina bifida occulta is a similar condition which has been produced by an arrest of development limited to the bone, and there is no protrusion of the membranes. In these cases there is apt to be a fatty tumor over the opening in the canal, with a local overgrowth of hair, and thickening of the skin. In spina bifida occulta and in cases of spontaneous cure, symptoms sometimes develop indicating pressure upon the cord or cauda equina, such as paralysis, anæsthesia, and trophic disturbances, and the pressure has been successfully relieved by operation in a few cases of this kind. Certain rare congenital cysts and fatty tumors of the spinal canal may protrude and confuse the surgeon, but the cysts are usually lobulated and the lipomata are not translucent. Spina bifida is frequently associated with many other congenital deformities, and also with hydrocephalus, and the worst prognosis is found in the latter cases.

Treatment.—The treatment by injection—drawing off a drachm or two of the fluid and injecting from one-half to one drachm of tincture of iodine or iodine glycerin solution (iodine, 10 grains; potassium iodide, 30 grains; glycerin, 1 ounce), has been successful in about one-half of the cases. The puncture is made obliquely through the sound skin at the side of the tumor with a hypodermic needle, full aseptic precautions being observed. In this method there is danger of paralysis when the nerves are involved, of septic complications and meningitis, and of subsequent leakage of cerebro-spinal fluid. Operative removal of the tumor has also given fair results, which are constantly improving. The dangers of operation are threefold: first, the shock and loss of blood at the time of operation; secondly, septic infection; and, thirdly, leakage of the cerebro-spinal fluid. There is also danger of injury and permanent paralysis of the nerves which are included in the sac. The operation is most successful in pure meningoceles having a small communication with the spinal canal. It is begun by dissecting back the skin from the tumor. If the pedicle of the sac is small, it is simply ligated; if large, the opening must be sutured, but the sac should be opened to ascertain whether any nerves are involved. If large nerve-trunks or the cord itself be included in the sac-wall, as proved by palpation, by seeing them through a thin sac, or by the presence of paralysis, no operation is allowable.

Operation should not be undertaken before the child is three months of age. In some cases successful attempts have been made to close the opening by making bone or periosteal flaps from the vertebral arches or the sacrum, or by grafting the periosteum of a rabbit on the closed sac.

SURGICAL DISEASES OF THE SPINAL CORD AND ITS MEMBRANES.

Inflammation.—Inflammation of the spinal meninges may follow similar affections of the head, or may arise from direct infection through an external wound, and the symptoms are spinal irritation, convulsions, and, finally, paralysis, together with a high fever. Purulent meningitis is rare, but when it has once set in treatment appears to be powerless, and a fatal end may be expected. In case of external infection the only available method of treatment is a free opening and drainage of the wound.

Tumors of the spinal cord are usually gliomata or tuberculous nodules, but they are rare. The tumors which chiefly occupy the surgeon are those which develop in the meninges, especially the dura, or in the bone, and compress the cord or involve it secondarily. These tumors are generally fibromata, sarcomata, or gummata. A tumor affecting the spinal cord may be suspected when motor and sensory paralysis below a certain point develops without known cause, especially if it be preceded by symptoms of irritation, such as increased reflexes, muscular spasm, spinal rigidity, and pain. Intense pain, often limited to certain nerves, is a common symptom, and sometimes local tenderness of the spine is observed. Tumors which did not involve the cord have been successfully removed by the operation of laminectomy.

INJURIES OF THE SPINAL CORD.

Concussion.—The symptoms recognized under the name of concussion of the spinal cord are due to slight lesions, such as very small lacerations, hemorrhages, or contusions. This condition has been known by the name of "railway spine," on account of its frequent production by railroad accidents. It appears to be most marked in persons of a neurotic temperament, and seems to depend largely upon the fright and cerebral shock received at the time of injury. The symptoms occasionally disappear as suddenly as hysterical affections.

Symptoms.—The fact that these cases are often complicated with lawsuits for the recovery of damages renders the interpretation of the reality of the symptoms still more difficult. The prevailing opinion at the present time is that such patients do not feign the symptoms they present, but that they are the subjects of a real nervous affection, although it is probable that the mind is affected as much as the spinal cord.

There are three types distinguishable among these cases, the picture presented being respectively that of neurasthenia, neuralgia, or paralysis, and in some cases any or all of the groups of symptoms may be combined. The neurasthenic patients, who are the most numerous, show a loss of memory and of will-power and have some pain in the back and a feeling of weakness, with congestion of the conjunctiva and more or less disturbance of all the bodily functions. The neuralgic patients suffer from severe shooting pains in various nerves, but particularly in the back and in the lower extremities.

Thirdly, the **paralytic** type of patients have a marked loss of power or even complete paralysis of one or more groups of muscles, especially of the lower extremities, and localized patches of anæsthesia. In all cases there is an exaggeration of the reflexes. These symptoms do not, as a rule, begin until some hours or days after the accident which causes them. It cannot be said that any one of these types is more difficult to cure or more likely to result in permanent disability than the others. Occasionally the symptoms disappear suddenly and completely without any adequate explanation, and if this disappearance happens to coincide with the winning of large damages in a lawsuit, great discredit may be thrown upon the patient and the experts, but unjustly, for many cases are on record in which even the winning of the suit has not succeeded in effecting a cure. Lawsuits, whether successful or not, are a detriment to a patient in this condition, for what he most needs is rest and freedom from responsibility and care.

Treatment.—Complete rest is the only method of treatment, except the administration of the usual tonics, hot and cold baths, massage, and gentle exercise, with a free out-door life. Occasionally some counter-irritation by a thorough cauterization over the spine is of advantage.

Laceration and contusion of the spinal cord, if extensive, is marked by paralysis corresponding to the portion of the cord involved, and is usually associated with severe fractures or dislocations of the spinal column. A complete recovery may take place even in severe cases, although this is usually slow. **Compression** of the spinal cord may be caused by displaced bone (from fracture or spinal caries), by blood-clot, or by a foreign body, such as a rifle-ball lodging in the canal. (Fig. 758.) **A hemorrhage** into the spinal membranes or the cord causes intense pain in the back, hyperæsthesia, muscular spasm, rigidity, the feeling of a cord tied about the waist, and rapidly developing paralysis, which is most complete when the clot is in the cord itself. In **compression caused by bone** the symptoms appear immediately at the time of the injury, they are apt to be more serious, and they may be permanent even after the bone has been removed. The location and the extent of the injury may be determined by the extent and the degree of the paralysis.

FIG. 758.

Gunshot fracture of cervical vertebra, showing ball encroaching on spinal canal.

Wounds of the Spinal Cord.—The cord may be completely divided by fractured or dislocated bones of the spinal column, and also by penetrating wounds by a knife, gunshot, or other missile. In the latter cases cerebro-spinal fluid may escape from the wound. These injuries may be of very limited extent and sharply defined, and they then produce clear-cut

symptoms, although immediately after the accident hemorrhage and œdema may cause symptoms resembling those of complete division of the cord, which may pass off leaving the limited paralysis. More frequently, however, considerable portions of the cord are injured, and the symptoms are extensive and not well defined. Septic complications appear to be unusual, and meningitis produces death in only about one-quarter of the cases. The paralysis generally remains permanently.

Treatment.—Successful surgical interference is as yet limited to the relief of compression, depressed bone being elevated, dislocations reduced, blood-clot evacuated from the substance of the cord or from the space between it and the membranes, and tumors removed. It is difficult to explain why wounds of the cord should not heal by primary union as well as those of nervous tissue elsewhere, but experiments made in this direction have not met with much success. This does not apply, however, to the nerve-roots, which may be united like the peripheral nerves with good results.

LAMINECTOMY.

Laminectomy is the operation of opening the spinal canal by cutting away the vertebral arches. An H-incision is often used, flaps being turned upward and downward, including the skin, muscles, and spinous processes, the arches being divided in the same lines on each side. A better method is the formation of a lateral flap by an incision over the arches upon one side, the periosteum and muscles being reflected to the bases of the spinous processes, the latter then being divided with bone forceps or chisel and lifted up in the flap, the dissection of which is continued towards the other side until the arches are exposed from end to end. The latter are then cut away. After recovery a fibrous cicatricial membrane closes the gap in the spine as efficiently as the original bone. By this operation depressed bone may be elevated or cut away, an abscess or a hæmatoma evacuated, tuberculous foci curetted, and tumors of the cord or surrounding parts extirpated. In severe neuralgia of the spinal nerves, especially when associated with muscular spasm, laminectomy has been performed and the posterior roots of the nerves divided within the canal. The mortality of laminectomy is said to be less than twenty per cent., in spite of the serious conditions for which it is undertaken.

CHAPTER XXXIII.

SURGERY OF THE BREAST.

ANOMALIES AND MALFORMATIONS.

Anomalies of the breast are of very frequent occurrence, the most common being the presence of supernumerary breasts, or **polymazia.** Absence of the breast, or **amazia,** is a very rare condition. Supernumerary breasts are usually found in the line of the mammary and epigastric arteries, extending down on the abdomen, often symmetrically, from two to four extra breasts being present. They are occasionally found in men. It is not infrequent for supernumerary breasts to occur in the axillary line just under the fold of the pectoralis major or high up in the axilla. The supernumerary breasts are generally provided with some sort of nipple. They vary in size, some being merely a little deposit of gland-tissue in the skin, while others are well developed. The nipple may be absent even when the breast is of good size, and in the case of axillary mammæ without a nipple a connection sufficient to allow the escape of secretion has sometimes been found between the supernumerary and the normal gland. Except for the possibility that tumors may develop in them, supernumerary breasts are of very little significance. Occasionally they are congested during lactation, and, especially if there is no nipple, the distention may be very painful.

The **nipple** of the normal breast also presents anomalies, being sometimes multiple and very rarely entirely absent. It is very frequently so badly developed that it is of little use for nursing, and a plastic operation has been suggested, consisting in the excision of elliptical pieces of skin on three or four sides, the long axis of the ellipses being on lines radiating from the nipple, and the widest part corresponding with the base of the nipple. The edges of the wounds are approximated by sutures, and a buried suture, introduced subcutaneously so as to cross the widest part of every ellipse and entirely surround the nipple, is tied loosely so as to gather in the skin at the proper place for the base of the nipple.

Hypertrophy.—*Atrophy* of the breast is a very common condition, but is of no clinical significance. *Hypertrophy,* however, produces very large tumors, which may be a great burden. (Fig. 759.) The structure of the gland appears to be exactly like that of the normal breast, with the exception that in some cases there is a marked increase of the fibrous stroma, but there is very little or no milk-producing power. The hypertrophy may be limited to one breast, but both are generally involved. It most commonly begins about puberty or during pregnancy, and the breast may attain an enormous size, reaching to the groin and weighing as much as sixty pounds.

The nipple is normal in most cases, though occasionally it is stretched out, and the areola is apt to be somewhat larger than normal.

Treatment.—The radical treatment of this condition is removal, although when the breasts are not too large some relief can be obtained by a properly fitting support for the heavy glands. The glands are very vascular, and an operation for this condition involves vessels of very large size. Occasionally greatly dilated veins are to be seen over the surface of the tumor.

Fig. 759.

Hypertrophy of one mamma in a girl aged fifteen.

INJURIES.

Injuries of the breast consist of wounds and contusions. In **wounds** of the breast the hemorrhage is likely to be severe, but the wounds unite readily, and in lactation there is seldom any escape of milk after the first few hours. **Contusions** of the breast may result in the production of a large swelling caused by blood-clot and œdema, and it is claimed that blows upon the breast may be the origin of a chronic mastitis or even of malignant disease; but in only ten or twelve per cent. of the cases of cancer is there any history of such an injury. The **treatment** of wounds of the breast does not differ from that of similar wounds elsewhere. Contusions are treated by the application of cold cloths, the ice-bag, and compression with a thick cotton dressing.

INFLAMMATION.

The nipple and the areola are subject to inflammations resulting from pyogenic and specific infection. The primary lesion of syphilis is often found here, a healthy woman having been infected by nursing a syphilitic child. Erosions and superficial ulcers of the nipple are not uncommon from nursing, and are a frequent cause of deeper inflammation in the breast. The **treatment** of these small lesions consists in absolute cleanliness of the parts and also of the infant's mouth, in suspending nursing or permitting it only at long intervals, and in touching the fissure with solid nitrate of silver. Proper attention to the development of the nipple before the child is born and to cleanliness afterwards will prevent fissures. No strong antiseptics can be used, for fear of poisoning the infant. An abscess may be limited to the nipple and areola, distending the nipple immensely, and sometimes discharging through one of the lacteal ducts. Obstruction of the ducts in the nipple may produce cysts, which may suppurate without any over-distention of the breast proper.

Acute Mastitis.—Mastitis, as inflammation of the breast is called, may be acute or chronic. The acute form is due to bacterial infection, which may take place through the milk-ducts, or through the lymphatic channels from an infection starting in some wound of the nipple or the skin. The inflammation may be limited to one lobe or may extend throughout the breast. It

is most common during the activity of the gland in the puerperal state, but is also found at other periods.

Puerperal Mastitis.—In the puerperal condition the infection generally arises from some erosion or wound of the nipple occasioned by suckling. The usual type of puerperal mastitis is one in which only one or two of the main lobes of the gland are involved. The breast presents a tender swelling, limited to a part or involving the entire mamma, for even if the abscess is limited to one lobe the congestion is liable to extend through the entire gland. There are pain and tenderness, œdema and redness of the skin, fever, and, possibly, a chill; in fact, the symptoms of acute inflammation. The diagnosis is to be made between mastitis and a simple congestion or retention of milk in the gland, or some of the acute varieties of neoplasm. The symptoms of simple congestion of the gland or of retention of milk caused by obstruction of the nipple closely resemble those of the early stages of inflammation; but, fortunately, the treatment is the same in the three conditions. The diagnosis of acute mastitis from a rapidly growing tumor may be exceedingly difficult, for a sarcoma may occasion a rise of temperature. Occasionally a fibro-adenoma of the gland increases suddenly with inflammatory symptoms during lactation, and then subsides to its original size and form. A delay of a few days ought to be sufficient to make the distinction between these conditions, as pus will soon appear in mastitis.

Prognosis.—The prognosis of puerperal mastitis is not bad. The inflammation in some cases will resolve; in most cases under prompt treatment it forms only a limited abscess, which heals when incised, leaving a small scar as the only result of the affection. Under bad treatment or in very virulent cases the inflammation may involve several lobes, each forming an abscess by itself, the cavities of which may or may not communicate, and great destruction of the tissues of the breast may result. Yet even in these cases recovery may take place under prompt treatment, and, in spite of the apparent destruction of its tissues, the breast is often quite as active in milk-production afterwards as one which has never been inflamed.

Treatment.—The treatment in the first stages consists in the application of an ice-bag, or simple compression with a thick cotton dressing and a firm bandage. If nursing with the other breast is continued, the nipple of the breast under compression should be left uncovered, so that milk can escape from it, but no nursing should be done upon that side. It is recommended by good authority that in the very earliest stages gentle massage of the breast should be made, and this treatment will often relieve an obstructed nipple. It is even possible that massage may dissipate functional congestion; but in the early stages of inflammation it would certainly do harm. If there is evidence of true infection, therefore, massage should never be employed, the application of cold, complete functional rest, and compression being the proper treatment. If there is an ulcer or abrasion of the nipple, it must be carefully cleansed and dressed in an aseptic manner. In the stage of abscess incision is necessary, and should be made as early as possible. Pus will form in two or three days, and should be immediately evacuated in order to prevent burrowing and further destruction of the tissues. The incisions for abscess should be made in radiating lines from the nipple, and if there is

more than one cavity, every one should be opened, the septa between them being broken down with the finger so as to allow of the freest drainage. If it is found that the first incision does not drain properly, another incision at the most dependent part of the abscess-cavity should be added. Gentle use of the curette to remove sloughs from the interior of the abscess is advisable if the case is one of long standing. These incisions are preferably made under general anæsthesia, although, if the abscesses are small and superficial, cocaine may answer. In neglected cases in which the breast is extensively involved, with numerous sinuses through which the pus has escaped, the latter should be thoroughly explored, and enlarged so as to admit of thorough curetting of their walls, and all the cavities should be well drained at the most dependent part. As soon as the inflammation subsides, strong compression should be made of the entire organ against the chest, so as to hasten the closing of the cavities. A wet dressing is allowable in the early stages of abscess, but the use of poultices should not be encouraged, because they may favor too great destruction of the gland-tissue. It is seldom that abscess occurs in the axillary lymph-nodes in consequence of abscess of the breast, although the latter frequently become swollen and tender.

Non-Puerperal Mastitis.—Mastitis may occur in the infant at birth or soon after, in virgins about the time of puberty, and even in the male. Corresponding with the smaller size and less vascularity of the breast, the symptoms are less acute, but abscess may form and require incision. Bryant suggests that some of the retracted and imperfect nipples so frequently seen may be the result of abscesses in infancy. It is a common thing for the breast of the new-born to be distended and to contain a little secretion, and it is not improbable that the formation of abscesses may be caused by the injudicious rubbing of the nurse or mother to dissipate this swelling. At or before puberty a subacute mastitis may closely simulate sarcoma, but the swelling can be cured by compression and a belladonna plaster.

Sloughing Mastitis.—In some cases there is a very acute and virulent infection causing a general inflammation of the entire gland, and resulting in acute sloughing of all its tissues, with all the signs of severe septic poisoning. These cases are fortunately very rare.

The **treatment** demanded consists in two or three very free incisions carried in the usual lines, but extending from the nipple to the margin of the breast, which should be made before pus forms, in order that tension may be relieved at once and some of the breast-tissue saved if possible.

Chronic Fistulæ are not infrequent as a result of abscess of the breast, especially when neglected, and sometimes milk is discharged from them, owing to the wound of a lacteal duct, but the escape of milk rarely continues more than a few days or weeks after the abscess has been opened. According to Bryant, a cure can be most readily obtained in the case of obstinate chronic fistulæ by confining the patient's arm to her side.

Subcutaneous and Retromammary Abscess.—In connection with mastitis we may speak of the subcutaneous and retromammary abscess. The subcutaneous tissue over the breast is liable to suppurative inflammation just as elsewhere, and not infrequently abscesses also form between the gland and the pectoral muscle. These may be acute or chronic, cold abscess

being quite common behind the breast as a result of caries of the ribs. The retromammary abscess usually forms a rather flat swelling, extending to the margin of the breast and pushing the gland forward in front of it. The diagnosis can generally be made by the great thickness of tissue which exists between the pus and the skin, and the even distention apparently affecting the whole region of the gland. In the case of cold abscess there will be an absence of acute symptoms. It is important to make the diagnosis in these cases in order that the abscess may be opened without cutting through the glandular tissue, which is easily done by a semilunar incision at the margin of the breast. The cold abscesses can sometimes be cured by aspiration, followed by injection of iodoform emulsion.

Chronic Mastitis.—Chronic mastitis may be either a slight infection of low grade, resulting in very slow suppuration, or a non-suppurative inflammation, affecting mainly the interstitial tissues of the breast. In the **suppurative form** small deposits of pus occur in the gland and may persist for months or years with few or no symptoms. They may be mistaken for malignant tumors, the nipple often being retracted and the skin adherent, and the abscesses usually being surrounded by indurated tissue. They may involve one lobe of the gland or the entire organ. It is not improbable that a large majority of these cases are instances of tuberculosis.

Interstitial chronic mastitis may involve only one lobe or the entire breast. It is shown by thickening of the fibrous stroma, the strands of which appear thickened, and microscopical examination reveals congestion of the tissues, with some round-cell infiltration and new production of fibrous tissue. The process may remain stationary or may slowly extend. It is frequently associated with the production of cysts, caused by obstruction of the milk-ducts or of the lymphatics, and the contents of these cysts—blood, milk, or serum—are apt to become very dark with age. The breast feels firmer than normal, and the fingers can recognize small, hard nodules and bands passing through it in different directions. In some cases the gland seems distended almost as if by a diffuse tumor or as if injected with wax.

Treatment.—There is no treatment for chronic mastitis except removal of the organ, and, as the condition sometimes results in the development of malignant disease, amputation is to be recommended when it is well marked. We have a specimen from a case of chronic mastitis which involved the whole breast and contained several cysts, showing on the margin of one of these cysts a minute patch of beginning carcinoma. This was the only particle of malignant disease in the gland, and the patient was still free from recurrence four years after the removal of the breast.

Tuberculosis of the Breast.—Tuberculosis of the breast, except as a result of extension from tuberculous glands in the axilla or from tuberculous disease in the chest or ribs, is rare. In the primary form the disease may occur at any age, although the great majority of the patients are between the thirtieth and fiftieth years. It seems to be equally common in male and female, and it has no connection with pregnancy or lactation. The disease may be diffused through the entire breast or limited to one lobe. It appears in the shape of a tuberculous infiltration with the forma-

tion of granulation-tissue and hard masses, or it may form cold abscesses, and sinuses frequently remain when the abscesses are allowed to break. In the nodular form the breast appears occupied by a tumor under normal skin, the gland not being adherent to the chest-wall, and the nipple not retracted. The surface of the breast is apt to be nodular. The glands in the axilla are seldom involved when the disease begins in the breast, but, as König has remarked, the great majority of the cases begin in the glands of the axilla and involve the breast secondarily. If the disease is seen in this stage before the sinuses form, the resemblance to a tumor is very close. The progress of the disease is very slow, and like that of tuberculosis of the soft parts elsewhere. The general health is not seriously affected, and the patient may have no trace of disease elsewhere, even when the mamma is reduced to a mass of indurated tuberculous tissue containing many small abscesses. In the great majority of cases, however, there are tuberculous lesions in other parts. The diagnosis of tuberculosis of the breast is easy if sinuses exist, but otherwise it may be impossible to distinguish between the nodular form and a malignant tumor, or between a cold abscess and a cyst. The presence of tuberculosis elsewhere will give a clue.

Treatment.—The best treatment is thorough removal of the diseased tissue, amputation being done, and the glands in the axilla removed also if they are involved. In the majority of cases the patient ultimately succumbs to pulmonary tuberculosis.

Syphilis of the Breast.—Syphilis of the breast appears quite often in the **primary** form, infection taking place from nursing. Various **secondary lesions** of the skin appear about the breast as elsewhere. In the late stages **gumma** is found, and sometimes produces extensive destruction of the gland-tissue. Gumma may form in the gland itself, in the subcutaneous tissue—involving the gland secondarily by ulceration, or in the retromammary tissue. In some cases the condition resembles a malignant tumor, hard or soft swellings being present, covered by healthy skin; but this error is rarely made, for, as a rule, a gumma spreads rapidly and soon ulcerates, producing the characteristic excavated ulcer with a sloughing centre and ragged undermined edges, more or less circular in shape. In doubtful cases a short treatment by antisyphilitics should settle the diagnosis. The **treatment** is the usual "mixed treatment" internally, aided by clearing out the sloughs and dressing the cavities with iodoform. The **prognosis** is excellent, the disease generally being quickly brought under control.

Mastodynia.—Mastodynia, or neuralgia of the breast, is an obstinate affection which is not uncommon, but is poorly understood. Neuralgic pains in the breast may arise from a great variety of causes, like neuralgia in general, but the form to which the name mastodynia has been given is usually found associated with a single tender spot in the breast. Not infrequently a small fibrous nodule can be found at this spot. As a rule, the symptoms are somewhat hysterical. The **treatment**, therefore, should be constitutional, including tonics, change of air, and an endeavor to distract the attention of the patient from the painful spot. Severe counter-irritation with the cautery will occasionally produce a good result. The application of a bel-

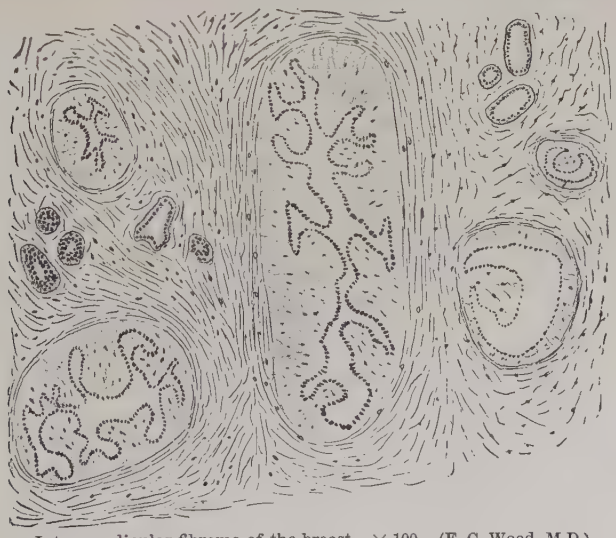
ladonna plaster, shaped to fit the breast and worn for some time, often gives the patient relief. In a few cases, when a distinct mass can be found, the pain is relieved by its excision.

TUMORS OF THE BREAST.

Lipoma, angioma, and **chondroma** are occasionally met with in the breast, but are of rare occurrence. The benign tumors ordinarily found are fibroma, adenoma, and certain cysts, and the malignant new growths are sarcoma and carcinoma. Myxoma and endothelioma form an intermediate class. Over eighty per cent. of the tumors of the breast are carcinomatous. A **pure fibroma** or a **pure adenoma** is a rarity, forming a well-encapsulated tumor, from the size of a hazel-nut to that of an English walnut, existing in the breast without symptoms, and usually discovered by accident. The great majority of tumors of this nature are mixed, containing fibrous and epithelial tissue in varying proportions, although the latter is often not increased in amount, and is simply the remains of the normal gland-tissue surrounded by the fibrous neoplasm. We shall, therefore, describe a fibro-adenoma as the typical form of these tumors.

Fibro-Adenoma.—Pathology.—Fibro-adenoma of the breast is of two varieties. **Ordinary Form.**—In the first form the stroma of the breast is thickened into fibrous bands, arranged in concentric layers or in bundles of interlacing fibres, enclosing between their meshes acini and ducts, either normal or slightly altered by pressure or stretching. These tumors vary in size from small nodules to masses infiltrating a quarter of the breast.

Fig. 760.



Intracanalicular fibroma of the breast. × 100. (F. C. Wood, M.D.)

They are usually well encapsulated, but in some cases there is no very distinct limit between the diseased tissue and the surrounding healthy gland, the intermediate portion representing sometimes the changes found in chronic mastitis, although with rather less cellular infiltration. The second

form of fibroma is the **intracanalicular**, in which the tumor grows into a lacteal duct and distends it. (Fig. 760.) The tumor may project into the distended canal as a smooth hemispherical or lobulated mass, or like a true papilloma. In rare instances these papillomatous outgrowths have been found projecting through the ducts at the nipple without any ulceration.

Cystic Changes.—In either form of fibro-adenoma cysts may be produced by dilatation of the acini and ducts, as the result of obstruction of the latter by fibrous contraction or pressure of the new growth, or cystic degeneration of the tissue of the tumor may take place. The cysts contain serous, mucoid, milky, or bloody fluids. (Fig. 761.)

Fig. 761.

Cystic fibro-adenoma of twenty years' duration.

Clinical History.—Fibro-adenoma is most frequent in adult life, especially from twenty to thirty years of age, although it has been observed at seven years, and also at seventy. The cystic tumors appear somewhat later than the solid. The growth of the solid tumors is slow (according to Gross, about two-thirds of an inch in diameter in one year), and they have few symptoms, except those due to the enlargement. The intracanalicular and cystic forms increase more rapidly, and they may enlarge steadily, or suddenly increase after a period of very slow growth, owing to the rapid development of cysts. They have been known to reach the size of a man's head in one year, and instances are on record in which they have weighed from twenty to thirty pounds. Occasionally they are tender and painful, but this is characteristic rather of the small single nodules. In about one-seventh of the cystic cases there is a serous or bloody discharge from the nipple, but this is absent in the solid variety. The nipple, as a rule, is unaltered, but may appear depressed relatively if the tumor develops near it. The skin is seldom adherent, but the veins may be dilated in large tumors. If the tumor is of considerable size it generally involves the entire breast. If it grows from one quadrant only, the remainder of the gland is spread out over it in a thin layer. In rare instances it may become pedunculated and hang from the side of the chest.

Multiple tumors of a fibro-adenomatous character are not infrequently found in the breast. It is rarely that ulceration takes place in fibro-adenoma, but the skin may become so stretched that it gives way and the mass of the tumor protrudes through the skin. When exposed in this way the tumor forms a papillomatous-looking mass, which projects from the opening and is liable to become infected and to ulcerate. This is more

common in the intracanalicular form. There is no metastasis to the glands or elsewhere, and the general health is not affected by these tumors. As nearly all the benign mammary tumors are fibro-adenomata, the chief point in the diagnosis is the distinction between them and the ordinary cysts and sarcoma, of both of which we shall speak later.

Treatment.—The only treatment possible is extirpation. When the tumor is small it may be enucleated from the breast, the gland itself being left untouched, and this is easy in the majority of cases on account of the encapsulation. But if the tumor is large, the entire breast should be removed. If the tumor is small, operation is not absolutely necessary, for we may be dealing with one of those tumors which will remain stationary or increase very slowly; but a full explanation should be made, and the patient should assume the responsibility, for many tumors that have remained stationary for years finally undergo sarcomatous degeneration. The surgeon should follow the rule to remove all tumors, even when confident of their benign character, as a part of the prophylactic treatment of cancer.

Sarcoma.—Pathology.—Sarcoma occurs in the breast in all its different varieties, about two-thirds of the cases being spindle-cell and one-quarter of them round-cell sarcoma, the least frequent being the giant-cell form. It is sometimes quite well encapsulated. Cystic degeneration is common. Sarcoma is characterized here, as elsewhere, by its rapid growth, but it is occasionally very slow, and in many cases tumors which had remained stationary for years have proved to be sarcoma. There are also cases in which a tumor has remained stationary for years and then suddenly become active and examination has shown it to be a sarcoma. Many of these cases are probably instances of malignant degeneration of a tumor originally a fibroma.

Clinical History.—Sarcoma generally begins at from thirty to fifty years of age, the cystic form rather earlier than the solid. Sarcoma of the breast usually appears as a tumor near the nipple, the size of a walnut or an egg when first noticed, soft and semi-fluctuating, or hard and often nodular, or varying in consistency in different parts. The skin is unaltered over it and not adherent to the tumor, which appears more or less movable in the breast, and entirely so on the tissues beneath. Pain may be present, especially if the tumor increases rapidly in size, but it is more frequently absent. There may be a bloody discharge from the nipple. The axillary glands are enlarged and involved in nearly one-sixth of the cases (Poulsen), but they do not feel so hard as in the epithelial growths. The tumor usually grows rapidly, reaching the size of the fist in a year or less. It may remain limited to that part of the breast in which it has originated until it attains a considerable size. The nipple is not retracted, although it may sometimes appear to be so because it is surrounded by projecting masses of the tumor. There is occasionally a discharge of bloody serum from the nipple. The skin over the tumor is tense, very seldom adherent, and the veins are dilated, but the dilatation often spoken of as pathognomonic of sarcoma is due to the large size of the growths, and is found with large benign tumors as well. The skin is seldom directly invaded (in ten per cent., according to Gross), but it may give way to the pressure from within, especially in

cystic tumors. The tumor may project through this opening, as in the case of fibro-adenoma, but this occurs much more commonly than in the latter growth, taking place in one-fifth of the cases. The tumor often protrudes without infiltrating the edges of the opening. In the later stages (Fig. 762) the tumor may attain a large size, invading the wall of the chest and the skin, and causing great pain and severe hemorrhages from the sloughing or ulcerating surface, but until this occurs the general health usually remains unaffected. Secondary tumors occur in over one-half of the cases, and are found in nearly all the organs of the body, but are most frequent in the lungs, liver, and brain. Secondary disease of the other breast or of the stomach and uterus has been noted, but is very rare. When secondary tumors once develop they frequently occur in many different organs, and the patient generally succumbs rapidly to the symptoms so produced, and dies of cachexia.

Fig. 762.

Advanced sarcoma of the breast. (Case of Dr. J. B. Deaver.)

The **diagnosis** of sarcoma is founded on its rapid growth, its soft and varying consistency, and the occasional infection of the lymph-nodes, all of which distinguish it from benign tumors. There may also be a slight increase in the temperature of the breast. From carcinoma it is differentiated by the greater rapidity of its growth, by the history of a sudden development of rapid growth in a tumor previously quiescent, by the indications of encapsulation, the freedom from adhesions to the skin and deeper tissues, the normal character of the nipple, and the absence of infection of the axillary glands in five-sixths of the cases.

The **prognosis** is hopeless unless operation is undertaken, death sometimes taking place within a year, and generally within three years, of the time the tumor is noticed. The results of treatment by operation are as yet in doubt, but it seems probable that from twenty-five to fifty per cent. of the cases may be saved by timely operation.

Treatment.—The proper operation is excision of the breast, including the fascia of the pectoral muscle and a clearing out of the axilla. The latter should always be done, even when there is no visible sign that the glands are involved, for the same reason as in carcinoma of the breast. In the incurable cases, little or nothing can be done except to give morphine and keep the parts protected and clean.

Myxoma.—Pure myxoma is not often found in the breast. It is a less malignant tumor than sarcoma, although it is to be noted that myxoma originating in the neighboring tissues may be very malignant. The tumors grow rather more slowly than sarcoma, and do not invade the lymphatics or cause metastatic deposits, but they not infrequently involve the skin, and they tend to return after operation in about one-sixth of the cases (Gross).

Myxoma is painful and forms tumors of varying consistency. Clinically they should be regarded as sarcomata, and should be removed by amputation of the breast and never merely enucleated.

Endothelioma.—In the breast endotheliomatous tumors may originate from the lining of the blood- or lymph-vessels, or from that of the lymph-spaces, and are commonly known as angiosarcomata. These tumors are single, movable, non-infiltrating tumors, not involving the lymph-nodes, but causing general metastasis. They occur in women over fifty years of age. They grow quite rapidly, and may be hard or soft; the skin tends to become adherent over them, but without the dimpling seen in carcinoma (Schmidt). Recurrence is very rapid, and from a clinical stand-point these tumors also must be classified with the sarcomata.

Carcinoma.—Varieties.—The clinical history of carcinoma of the mamma varies with the structure of the tumor, according to the relative proportion of the epithelial cells and the fibrous tissue. An abundant growth of epithelial cells and a scanty fibrous stroma indicate an actively malignant course for the disease. Those tumors in which the fibrous tissue is abundant are known as scirrhus. We may distinguish clinically five types of carcinoma: 1st, ordinary carcinoma; 2d, soft carcinoma, or encephaloid; 3d, scirrhus, in the ordinary form of which there is considerable fibrous tissue; 4th, atrophic scirrhus, which contains very few epithelial cells; and, 5th, a rare form, known as **colloid carcinoma.** The colloid form can be dismissed with a few words, as it is very rare and of little clinical importance. The tumors are very slow in growth, and have a tendency to the formation of cysts containing a colloid material. Clinically, the tumors are densely hard, nodular, do not ulcerate very rapidly, and the skin is not involved early. The nipple is retracted and the glands are invaded, but the course of the disease is a slow one, the patients living ten years or more. Cystic degeneration of ordinary carcinoma is rare.

Clinical History.—Carcinoma appears most commonly about the climacteric, on the average at forty-eight years of age, rarely before thirty or after seventy years, and apparently without reference to marriage, childbirth, or nursing. In a small percentage of cases an acute mastitis or a blow upon the breast appears to be the direct cause. There is no difference between the right and left breasts in liability to the disease. The tumors grow with considerable rapidity in the ordinary cases, on the average reaching the *size* of a hen's egg in from six months to two years. They are *situated* at any part of the gland, but are most frequently found in the upper and outer quadrants. They also frequently lie directly under the nipple, occupying the central part of the gland. The most dangerous situation is that in the upper inner quadrant, where infection of the lymphatics within the chest and above the clavicle occurs early. In rare cases the entire gland is attacked at once. In a few cases the second breast becomes cancerous, but this is probably an independent tumor and not a metastasis from the first. (See Fig. 765.) After the presence of the tumor has been noticed for from a few weeks to a year or more, the *axillary glands* can be felt enlarged, the average time being about fourteen months, and they are present in over two-thirds of the cases at the first examination. Instances have been noted, however, in which the

glands appeared to be involved from the very first, and others in which they were free, even after the disease had lasted for years. We have removed a scirrhous carcinoma from an aged woman, with a history of six or seven years' duration, in which the glands showed no trace of involvement. (See Fig. 764.) In the later stages the pressure of the glands upon the axillary vein causes great œdema of the arm. (Fig. 763.) The *skin becomes adherent* to the tumor in about fifteen months (Gross), but occasionally a few weeks after the tumor appears. This adhesion of the skin is caused by the traction of the new growth on the fibrous stroma of the gland, which is continuous through the capsule with the subcutaneous fibrous tissue. *Ulceration* takes place in about eighteen months, although it may be absent even in tumors which have existed for a long time and in which the skin is evidently involved in the process. The *nipple is retracted* in the majority of cases, this change being evident during the first six months. According to Gross, retraction is found in fifty-two per cent., but in our experience it is exceptional not to find it, although it may be delayed for a year or more. A *discharge from the nipple* is sometimes seen, being usually bloody or serous, and occasionally milky.

Fig. 763.

Extreme œdema of the arm from carcinoma of breast. (Case of Dr. J. B. Deaver.)

Pain is generally absent in the first stages of the disease, and this fact cannot be too much insisted upon, for it is a common error to suppose that malignant disease is invariably painful. The pain, as a rule, is slight until the tumor has attained a considerable size or the disease has progressed into the axilla, where it presses upon the nerves, and then it may be excruciating. The *breast becomes fixed* upon the pectoral muscle near the end of the second year, although this change has been observed even in the first three months. *Cachexia* follows when the ulceration has been marked and some septic absorption has taken place, when there has been much loss of blood or great pain, or, finally, when the secondary deposits in important organs have interfered with the bodily functions. The *secondary tumors* are found in all organs of the body, most frequently in the lungs and the liver, more rarely in the bones and the brain. It should be noted that metastasis frequently takes place before the lymph-nodes are involved.

The **ordinary carcinoma**, as a rule, is a tumor the size of an English walnut, or perhaps as large as a hen's egg when first seen, densely hard, smooth or nodular on the surface, generally adherent to the skin, the nipple slightly retracted, and with one or two small glands to be felt in the axilla, the breast being movable upon the pectoral muscle. In some cases there will be early ulceration of the skin even in tumors of this size, and in others the axillary involvement will be far in advance of the development in the breast. In the soft variety of carcinoma (**encephaloid**) the growth is more rapid, the tumor is likely to be much larger when first noticed, and ulceration may take place very early. In cancerous ulceration the skin becomes

infiltrated and dark purple; it then breaks down and an ulcer is formed with a red or yellow sloughing base or covered with masses of malignant tissue resembling huge dark-red or pale granulations. Even in this stage the breast may be free from the pectoral muscle. The later symptoms in these two varieties consist in the fixation of the breast on the pectoral muscle, the involvement of the glands in the axilla, the appearance of glands in the neck, the extension of the ulceration, and the symptoms caused by secondary growths. Hemorrhage from the ulcers may be very free, but is seldom immediately fatal unless the ulceration has penetrated some of the large axillary vessels.

In **scirrhus** the tumor is rather small, and the affected breast may appear actually smaller than its fellow. It will usually involve most of the breast when first observed, although it may exist merely as a nodule the size of an English walnut. The skin is very adherent, and if the breast is reduced in size the skin is drawn into deep folds and wrinkled, and the nipple may be retracted out of sight. The glands in the axilla are generally involved but slightly. The cut surfaces of the tumor become concave, and it is very crisp on section, even creaking under the knife. The progress of scirrhus is generally marked by some enlargement of the tumor, and the breast may be twice the natural size unless ulceration takes place. The breast becomes adherent to the pectoral muscle comparatively early, and the skin is likely to show patches of epithelial growth.

Atrophic scirrhus is a rare form of the disease, in which the breast shrinks away, no tumor being formed. The skin is more or less adherent, the nipple disappears, the entire breast is flattened and shrunken. The glands are involved late, although occasionally a large mass of glands will be found with a very atrophic breast. This form of the disease is, as a rule, very insidious in its development, and the breast has almost disappeared before the patient, who is usually advanced in age, recognizes that there is anything wrong with it. In some cases ulceration sets in comparatively early, but usually the same slow progress characterizes the ulceration, which spreads very little into the surrounding parts. (Fig. 764.)

Fig. 764.

Scirrhus of breast of seven years' duration.

Dissemination of epithelial growth in the skin is occasionally seen accompanying scirrhus, or even ordinary carcinoma, but it is most commonly observed in recurrent tumors. Hard patches appear in the skin in the neighborhood of the scar of the previous operation, of a pink or dusky red, often with dilated capillaries visible to the naked eye. These patches are very numerous and gradually appear at distant points, spreading from the scar as a centre. Where the patches are thickest they run together, forming large, flat masses; but, as a rule, in the greater part of their extent they remain discrete. The disease spreads slowly or

rapidly over the side of the chest, and may involve one-half of the thorax, or even the entire upper half of the body, and extend well down upon the arms. The skin in this region is thickened by the infiltration, slightly reddened, breaking down here and there in superficial ulcerations. This variety of the disease may run a course of three or four years. The pain is usually slight, but an annoying irritation and burning is occasionally felt in the nodules. The discharge from the ulcerated surfaces may be very troublesome. The term *cancer en cuirasse* is properly applied to a dissemination of cancer in the skin with atrophic contracting changes.

Diagnosis.—Carcinoma of the breast is distinguished from benign tumors by its rather rapid growth, by the tendency to adhesion of the skin, by retraction of the nipple, by the fixation of the gland on the pectoral muscle, and, finally, by the enlargement of the lymph-nodes in the axilla. We do not speak of the later symptoms, such as ulceration, for to be of any value the diagnosis must be made before this occurs. In differentiating carcinoma from sarcoma the former is marked by the more advanced age of the patient, the early adhesion of the skin, the involvement of the lymph-nodes, and the slower growth of the tumor.

FIG. 765.

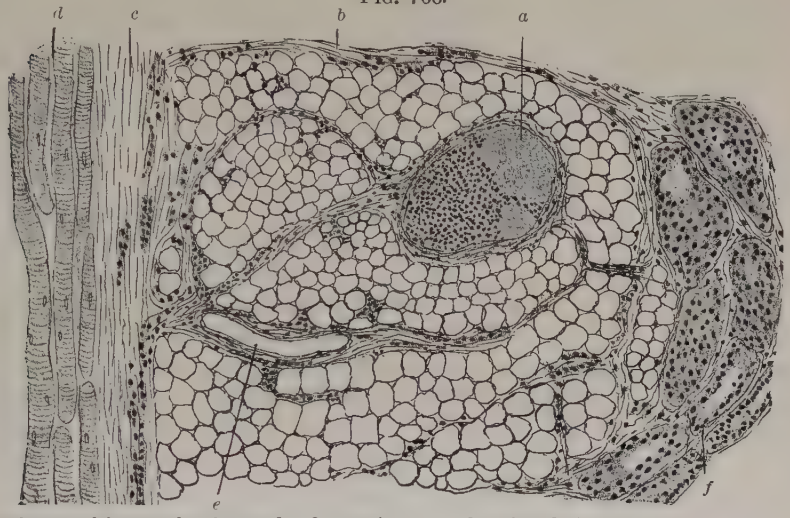
Result of operations for carcinoma of both breasts. 1889, left breast removed; 1890, scar and left pectoralis major; 1892, right breast and pectoralis major removed; three years later, no return.

Prognosis.—Death is inevitable unless the patient dies of some other disease before the cancer reaches its termination. The usual duration without operation appears to be nearly two years and a half. A radical operation will cure from twenty to thirty per cent., and even more in selected cases, while the operation generally prolongs life. The mortality of the operation should not be over two or three per cent. Pregnancy hastens the growth and dissemination of these tumors, but there is no evidence that the youth of the patients has this effect.

Treatment.—The treatment consists in complete removal of the diseased organ, together with the contents of the axilla. The fascia covering the pectoral muscle must also be removed, because it has been shown that the lymphatics of the breast penetrate the capsule and ramify in the loose connective tissue between the breast and the fascia, and that infection of these lymphatics takes place very early. (Fig. 766.) If isolated glands are removed from the axilla, the lymphatic vessels which connect them with the breast and with one another are left undisturbed; therefore the entire mass of fat and cellular tissue from the edge of the breast up to the apex of the axilla, including the glands and their vessels, must be removed in one piece. This much should be done in every case of carcinoma of the breast, no matter how small the tumor and how limited the infection may seem, for

it is known that glands buried in the axillary fat may be considerably enlarged and yet may escape detection through the skin. It is also known that when infection takes place the size of the glands may not be perceptibly increased in the early stages, and many glands which appear perfectly normal are found to be carcinomatous at the centre.

Fig. 766.



Carcinoma of breast, showing mode of extension: *a*, a lymph-node infected at its lower part; *b*, a lymphatic channel in the fat, containing cells from the cancer; *c*, fascia over the pectoralis major (the cells infiltrate it but do not involve the muscle beneath); *d*, pectoralis major; *e*, veins; *f*, the edge of the carcinoma. (F. C. Wood, M.D.)

The Typical Operation.—The incision should circumscribe the skin over the tumor and the nipple and areola. If the skin is adherent, the incision should pass two or three inches away from the nearest adherent point; if it is not adherent, it will be sufficient to sacrifice that part of the skin which lies directly over the tumor. The incision should always lie at least half an inch away from the areola. The amount of skin to be removed being outlined, it will usually be found that an elliptical incision has been made, and it should then be extended, if necessary, in an oblique line from the ensiform cartilage upward into the axilla just below the pectoral fold. The skin is to be dissected up on each side of the part to be removed, keeping clear of the surface of the breast until the flaps have been raised beyond the edge of the gland in all directions. The pectoral fascia is then divided at the edge of the breast, and the deep fascia towards the abdomen is divided also. The gland and the tumor are to be turned up with the pectoral fascia, leaving the fibres of the muscle as clean as in an anatomical preparation. The fascia is to be pared off the posterior edge of the pectoral muscle at the same time, and stripped from the side of the chest up towards the axilla. The edge of the pectoralis minor forms a guide to the axillary vessels, and the fascia at the apex of the axilla is to be cautiously opened by being picked up with forceps and snipped with scissors. As soon as the axillary fat is exposed it is separated cleanly from the axillary vessels, leaving the mass of

fat and glands in connection with the breast and removing the whole in one piece. With care the third subscapular nerve can be preserved, and its injury should be avoided, because it supplies the latissimus dorsi. Some surgeons prefer to open the axilla first and remove the contents, in order to prevent all danger of infection by forcing cancer-cells into the vessels by the handling of the parts, and then excise the breast, but the usual practice is that given above, and it seems easier of execution and sufficiently safe.

This method is suited to the removal of the breast when it is not adherent to the pectoral muscle, but as soon as the gland has become adherent the entire muscle should be removed (Heidenhain). In such cases, when the skin-flaps are made, the upper and inner flap should be dissected well back to the edge of the insertion of the pectoralis major. The space under this muscle being opened, the finger rapidly separates it from the pectoralis minor, and then its insertions into the ribs towards the sternum are divided with the scissors and the entire muscle drawn outward, together with the breast and the tumor. Before dissecting the axilla the insertion of the pectoralis major into the humerus is to be exposed and divided. When the axilla has been cleared, in such cases as these, the dissection should be carried under the pectoralis minor, and the triangle of Mohrenheim, which lies on the inner side of the pectoralis minor, between it and the clavicle, should be cleared of its fat, vessels, and lymphatics. In very bad cases in which the diseased glands can be felt high up under the pectoralis minor, that muscle should also be divided transversely, in order to facilitate the dissection of the apex of the axilla (Meyer). The divided muscle is sutured at the close of the operation. When the diseased parts have been entirely removed, the vessels are ligated and the flaps turned back in place, and the wound is sutured. If much skin has been removed, additional skin may be obtained by dissecting it up from the side of the chest or the abdomen, so as to enable the flaps to slide inward. A space the size of the palm of the hand, or even larger, can thus be covered. If a raw surface remains, it can be covered with Thiersch's skin-grafts, either immediately or after granulation has begun. In the majority of cases, if the wound is sutured, it is wise to employ drainage, in order to prevent an accumulation of blood.

Paget's Disease.—A peculiar epitheliomatous disease of the nipple is known as Paget's disease. It begins as an eczematous condition of the nipple, involving its entire surface and more or less of the areola. In this stage the skin seems superficially thickened, but is still soft, and there is no true ulceration, merely a rapid desquamation of the superficial epithelium. Shallow ulceration occurs, and the edges of the ulcer become thickened. The ulcer may be limited to the nipple, and the latter may gradually disappear, its former situation being marked by a small granulating ulcer level with the skin. The secretion is very slight, occasionally bloody. Probably from an early period some thickening of the breast-tissue can be discovered underneath the nipple, and this induration gradually spreads throughout the breast. The disease is very slow in its progress, often lasting several years, but it is sure to terminate in true carcinoma of the breast. The early pathological changes are those of chronic inflammation and superficial desquamation of the epithelium of the skin. The cornification extends more

deeply than normal, and a careful search will show some places in which the epithelial cells have begun to penetrate the basement membrane, as in true epithelioma. One theory as to Paget's disease assumes that it begins as an eczema, becoming malignant from long-continued irritation; another theory asserts more correctly that the disease is an epithelioma from the first, beginning in the mouths of the lacteal ducts (Thin). It should be noted that an ordinary epithelioma of the nipple also occurs in rare cases. The **diagnosis** of Paget's disease from simple eczema of the nipple and ulcerative processes due to infection can generally be made by the strict limitation of the ulceration to the nipple and by the obstinately chronic character of the disease. The **prognosis** in cases left without treatment is hopeless. While local **treatment** may be of value in the very earliest stages, the only rational course after ulceration has begun consists in the typical removal of the entire breast.

Cysts.—Cystic degeneration of tumors of the breast is quite common, but true cysts of the gland form only two per cent. of its tumors, according to Gross. They are of three kinds—epithelial, lymphatic, and parasitic (hydatid). The epithelial cysts may be divided into the so-called involution cysts and retention cysts. The changes in the breast associated with its atrophy after lactation or in old age produce **involution cysts** similar to such cysts in other glandular organs. In these cysts, which are always of small size, the atrophying tissue retracts and draws on the walls of the acini, which distend under the traction, and at the same time it obstructs the canals and causes dilatation. These cysts usually have very thin walls, contain a thin serous fluid, and appear as tense swellings half an inch or so in diameter, which are easily felt when directly beneath the skin, but may resemble solid tumors if they are deep in the breast. Very seldom is there a discharge from the nipple. If the cysts are small, multiple, and deeply placed, the breast may very readily be supposed to be the seat of cancer. Simple evacuation of the contents of the single cysts by a hypodermic syringe confirms the diagnosis and frequently effects a cure.

Retention cysts are caused by obstruction of some of the lacteal ducts by inflammatory swelling, by a cicatrix, or by the growth of a tumor. In these cysts the cavity is made up of one or more acini, and may include an entire lobe. The cavity may be single or divided into several chambers. The contents of the cyst may be a milky fluid, or may resemble butter or cheese, *galactocele;* or it may be serous or bloody and dark, being discolored by hæmoglobin. These cysts sometimes attain a large size, especially the galactoceles—cysts holding several ounces, or even nine pounds, of fluid, having been reported, but they are seldom as large as a hen's egg. They are seen in the active period of the gland in middle life, and frequently follow pregnancy. A discharge from the nipple is found in about one-fifth of the cases. The cysts are single in two-thirds of the cases, and the lacteal cysts are always single, according to Gross. They seldom become inflamed.

Diagnosis.—The diagnosis of retention cysts is tolerably easy if they are fairly large, by their tension or fluctuation, slow development, and lack of invasion of surrounding parts. The skin is not adherent unless they become inflamed, and the nipple is not retracted, although it may be pushed aside

or even buried between the protruding cysts. The galactoceles are generally easily recognized by their rapid growth during lactation, without pain and without great tension.

Reclus has described a **cystic disease of the breast** which is marked by the formation of multiple cysts, generally of small size, dispersed throughout the organ. It occurs after the menopause, like the involution cysts, but in addition to the formation of cysts there is some fibro-adenomatous change of the tissues, and the disease is probably to be looked upon as a neoplasm. In two-thirds of the cases it occurs in only one breast. It progresses slowly, sometimes forming tumors of considerable size, and is difficult to distinguish from chronic interstitial mastitis and from fibro-adenoma. The course of the disease is benign, but the French observers assert that it is apt to be converted into malignant disease later.

Lymphatic cysts develop in the fibrous stroma, but they are rare. They have occasionally caused the removal of the breast under the supposition that cancer was present. They occur after the menopause, as deep-seated, single or multiple cysts, tense, and not fluctuating. They are lined with endothelium, and their contents are said not to contain albumin.

Mention should also be made of the presence of **hydatid cysts** in the breast, although these are rare, particularly in America.

The **treatment** of cysts is evacuation of their contents by aspiration or incision, and, if they return, the injection of iodine or pure carbolic acid. Galactoceles may require extirpation, because they are lined with an active secreting epithelium, and they should be removed with as little damage to the breast-tissue as possible.

Tumors of the Mammary Region.—**Sebaceous cysts** appear in the skin over the breast, and particularly in the sebaceous glands of the nipple. **Dermoid cysts** are rare. **Angioma** may develop on the skin of the breast, and occasionally it has been observed in the nipple, forming pendulous tumors requiring removal. Painless **fibroid tumors** have been observed on the skin of the breast, and these, too, should be removed. **Epithelioma** of the skin of the breast, while rare, is occasionally met with, and runs the ordinary course. **Lipoma** is found in the subcutaneous fat over the breast, and sometimes forms large tumors behind the gland, developing between it and the pectoral muscles. The latter tumors are often taken for an abscess, or a malignant tumor of the breast itself. The **treatment** of all these tumors is removal. Benign tumors situated behind the breast can be removed by a semicircular incision following the lower border of the gland and lifting the latter from the chest.

DISEASES OF THE MALE BREAST.

Although an atrophied organ in the male, the mamma is liable to chronic mastitis, and carcinoma is found quite frequently—about one case to one hundred in the female. It usually runs rather a slow course, but is apt to be discovered too late to allow of a permanent cure by operation. The ordinary scirrhus is the common variety. The local changes and the symptoms of these conditions are similar to those in the female.

CHAPTER XXXIV.

SURGERY OF THE ABDOMEN.

INJURIES OF THE ABDOMEN.

Pathology.—Contusions of the abdomen are often the result of so-called "bumper accidents," the body being caught between two cars in motion, or between the tail of a cart and a wall, and they are also very frequently produced by kicks from horses. The great danger in these injuries is the liability to serious damage to the abdominal viscera or the great vessels, and it is possible for rupture or laceration of these organs to be produced without ecchymosis or other trace of injury on the skin. Laceration of the stomach and intestines is exceedingly dangerous, on account of the large number of bacteria in their contents and the certainty of peritonitis. The solid organs, such as the liver, kidney, and spleen, are lacerated by the pressure of the blow. The bladder is ruptured by the force of the blow when distended, because its contents cannot escape, but laceration of the stomach and intestine is probably produced by the crushing of the organs against the vertebral column. The walls of the stomach and bowel may be contused and slough later, when perforative peritonitis will not develop for some hours after the injury.

Wounds of the abdominal wall, whether gunshot or incised, if they involve only the skin and muscle, are not of great importance, except that a hernia is likely to form in the scar if the muscles be widely divided unless they are properly united. **Penetrating wounds** of the abdomen are very serious, even if small. They may simply open the peritoneal cavity, rendering it liable to infection, or they may divide the abdominal walls so freely that some of the contained organs prolapse in whole or in part, and in almost every case a fragment of the omentum protrudes. The chief danger in these wounds is the development of peritonitis. The viscera may be injured by the penetrating object. In gunshot injuries the ball may pass through both walls of the abdomen, perforating any of the viscera or the vessels in its course. The canal through the solid viscera will be straight, but the passage of the missile through the intestine and stomach may produce many openings, because those organs may be folded upon themselves, and as many as twenty or thirty perforations of the intestine have been caused by a single bullet. The bullet may be arrested in any part of its course, and it has often been found inside of one of the hollow organs. It has been vomited with the contents of the stomach, having penetrated only one wall of that organ; it has been passed with the feces, proving that it entered the bowel; and it has been found enclosed in the gall-bladder at autopsy years afterwards, the patient having made a complete recovery. Bullets may pass entirely

through the abdomen without wounding any of the viscera, but such cases are very great rarities, and it is safe to assume that when a ball has passed through the abdomen some of the organs have been injured.

Incised or stab wounds of the abdomen may or may not injure the contained viscera. The liability to visceral injury by cutting weapons is less than that by bullets, the velocity being less and the organs having time to retreat before the weapon. The liver, kidney, and bladder may be reached by cutting weapons without involving the peritoneal cavity and without danger of subsequent peritonitis.

Symptoms and Diagnosis.—The first effect of the abdominal injury is shown in the shock. The shock of stab wounds is greater than that of gunshot wounds, while that of severe contusions of the abdomen with injury to the viscera is still more violent. The shock manifests itself by failure of the pulse, superficial respiration, and cold sweating, and occasionally by vomiting. The pain produced by these injuries is very variable, and depends largely upon the amount of extravasation of the contents of the injured organ. The signs of hemorrhage often form an essential part of the primary symptoms, and the loss of blood may result fatally in a few minutes if the liver or spleen is ruptured or if one of the large vessels has been severed. In the milder cases the distinction between shock and hemorrhage is not easy, but the latter usually causes shooting pains running down the limbs, restlessness, and rapid respiration, with persistent consciousness. When the hemorrhage is very copious there may be dulness on percussion in the dependent parts of the abdomen from the effused blood. The abdominal wall is held against the liver by the atmospheric pressure, and if gas from the intestine enters the peritoneal cavity it causes a separation to take place between the two, and a tympanitic note from the layer of gas takes the place of the usual dulness on percussion due to the liver. This disappearance of the liver dulness is considered a pathognomonic sign of perforation of the stomach or intestine, but it is not absolutely reliable unless there is evidence that the liver dulness existed just before the accident. A fold of the colon may be thrown up between the liver and the abdominal wall, and thus simulate the falling away of the liver caused by free gas. On the other hand, adhesions may hold the liver against the abdominal wall even when gas is present, or the gas may be confined by adhesions around the organ from which it escapes, so that it cannot reach the hepatic region. The escape of gas, however, through an external wound in cases of recent injury may be relied upon as evidence of perforation of the stomach or the bowel. Rupture of the spleen may occasion severe and even fatal hemorrhage without other symptoms, or there may be vomiting and pain in the left shoulder. Laceration of the great vessels also presents only the symptoms of internal hemorrhage. Laceration of the liver may be recognized by the signs of severe hemorrhage in the first stage, followed by tenderness over the organ and pain in the right shoulder, and occasionally by a low grade of peritonitis, caused by the escape of bile into the peritoneal cavity. The peritonitis after this accident is occasionally acute, and, on the other hand, the peritoneal cavity has been found to contain large quantities of bile, with scarcely any sign of inflammation. Rupture of the kidney will be recognized by the

signs of internal hemorrhage, the appearance of blood in the urine, and the formation of a retroperitoneal tumor of considerable size about the kidney, caused by the extravasated blood. Rupture of the bladder will be recognized by inability to pass the urine, and the retention may be accompanied by tenesmus. If cystitis be present, a very acute peritonitis may follow the accident, but the peritoneum reacts slowly to healthy urine, and in some cases the symptoms of inflammation have been obscure for three or four days after the accident. Rupture of the bladder may also take place in that part of the organ which is not covered with peritoneum, in which case urine is extravasated in the cellular tissue, and results in the formation of abscesses in the pelvis and lower part of the abdomen. An injury of the stomach, if slight, may be accompanied by vomiting, and bright blood may be thrown up, but when the wound is extensive vomiting is impossible. Peritonitis sets in quite promptly, and food may find its way through the wound into the peritoneal cavity, and produce intense pain, as in perforation of the stomach by an ulcer. The wound of the stomach may be situated on the posterior wall, and a subphrenic abscess will then result instead of a general peritonitis. In very small punctured wounds of the stomach and intestine the mucous membrane generally becomes everted, blocking the opening and preventing escape of the contents. Meanwhile adhesions may form, and an abscess or spontaneous closure and recovery may result, but this fortunate conclusion is very rare. Laceration of the intestine is followed by the production of a localized or general peritonitis, according to the size of the wound and the amount of fecal extravasation. In none of these latter accidents is hemorrhage an important factor, unless there has been some injury of the mesentery as well. Injury of the large intestine is less dangerous than that of the small, as the contents are likely to be more solid and the fecal extravasation is less extensive. The introduction of hydrogen gas into the bowel to determine if a perforation is present is dangerous, as it increases the existing tympanites and may cause additional fecal extravasation.

Treatment.—The treatment of these injuries depends upon the particular organ involved, and in the first place one should determine, if possible, whether any of the viscera have been injured. This diagnosis must be made before peritonitis develops, for if interference is delayed until symptoms of peritonitis appear it will be too late usually to save the patient. The results of the earliest laparotomies are not good, the mortality being from fifty to seventy-five per cent. It is estimated that contusion of the abdomen with rupture of the liver or spleen results in death in about five-sixths of the cases. Injuries of the stomach and intestine, if left untreated, have a mortality even higher than this, although instances of spontaneous recovery are not unknown when the perforation was small. It may be considered settled that if a patient has suffered from an injury severe enough to make it probable that one of the abdominal organs has been injured and that there is danger of peritonitis, laparotomy should be performed, provided that it can be done within from twelve to twenty-four hours after the accident by a surgeon of experience and with all the facilities of a modern hospital. If such advantages are not at hand, it is wiser to trust to nature for a recovery. Laparotomy for gunshot wounds will probably never be a successful feature

of military surgery, because it is impossible on the field to secure the facilities for performing this heroic operation, and it is too late to attempt it by the time the wounded reach the main hospitals.

Operations of this kind, whether in cases of contusion or of gunshot wound, are performed like any ordinary laparotomy, except that great rapidity of execution is necessary in order to lessen the shock. If the patient is already in severe shock from the injury, the operation should be deferred until reaction has been obtained. During the operation the abdomen and all exposed viscera must be kept carefully covered with hot damp cloths. The incision should be sufficiently large to permit rapid examination of the abdomen. The situation of the contusion or wound is the guide to the organ injured, and this region should first be examined and any wounds treated as necessary. But the surgeon should not be content with this, and every part of the abdomen should be carefully explored, for it has frequently occurred that one wound of the intestine has been found and treated, while other injuries have been overlooked. Single wounds of the gut or stomach are closed by Lembert sutures, or, if the bowel has been entirely divided, a Murphy button or lateral anastomosis should be employed. If there are several wounds close together, the entire loop of bowel should be resected. Wounds of the bowel can sometimes be closed most rapidly by stitching the serous surface of a neighboring loop of intestine against the open wound. It may be necessary to secure the open ends of the bowel in the abdominal wound without attempting to suture them, if the patient is in collapse. If a large quantity of blood is found on opening the abdomen, the operator or his first assistant should immediately compress the aorta at the root of the mesentery with one hand while the wounded part is being sought for. The lacerated spleen should be removed after ligature of the pedicle. Wounds of the liver may be brought together and all hemorrhage controlled by a few deep sutures, or they may be packed with gauze. Injury to the mesenteric vessels requires resection of as much of the bowel as has its circulation impaired. The injury to the viscera having been dealt with, the wound is to be rapidly closed. If fecal extravasation has occurred, the peritoneal cavity should be washed out and a drainage-tube inserted. (For the treatment of injuries of the kidney and bladder, see those chapters.)

Wounds of the abdominal wall without injury to the viscera are to be closed by sutures after careful sterilization. The wound should be wiped out thoroughly and carefully packed with gauze, then the skin is to be cleaned and sterilized, and, finally, the wound itself washed with the sterilizing solutions, with due care that none enters the peritoneal cavity. If the omentum prolapses, the protruding part should be ligated, cut away, and the stump replaced. The prolapsed viscera should be cleansed and returned, the wound being enlarged, if necessary. The prolapsed spleen has frequently been ligated and removed with a successful result.

THE GENERAL TECHNIQUE OF ABDOMINAL SURGERY.

The opening of the peritoneal cavity has usually been called laparotomy, but some prefer the term cœliotomy for such operations, whether the cavity is opened through the abdominal wall or through the vagina.

The Incision.—Nearly all operations upon the abdominal organs require the opening of the peritoneal cavity, and the incision usually chosen is in the median line, although it is not absolutely necessary to confine it to the linea alba. The hemorrhage is least and the adjustment of the edges easiest at this point. Other incisions, vertical, oblique, or transverse, may also be made through the abdominal muscles, but the different layers of muscle are difficult to approximate, and a hernia or weakness of the abdominal wall is more to be feared. This defect is less important in the upper part of the abdomen, because the intra-abdominal pressure is not so great as below the navel, and hernia is less likely to develop. For operating on the diseased appendix without suppuration, McBurney has suggested that after the skin has been incised the fibres of the abdominal muscles should be separated in the direction of their length, the opening in the external oblique being therefore at right angles to that in the internal oblique. The opening thus obtained is about two inches in diameter, and after the operation, when the muscular fibres are brought together, the lines of incision in the two muscles cross each other, and firm support is given to the abdominal contents. The size of the incision must be proportionate to the work to be done. Solid tumors require larger incisions than cystic, because the size of the latter may be reduced by aspirating their contents. Any dissection or the introduction of sutures deep in the abdomen also requires large incisions, and while the expert may venture to separate adhesions by touch only, and to work through a small opening, the majority of surgeons should see clearly what they do. In making an abdominal incision the skin and muscles or aponeuroses are divided down to the peritoneum, and all bleeding vessels secured before opening that membrane. The peritoneum is then picked up between two forceps and lifted free from the underlying omentum or bowel. A small opening having been made in it, the air enters and the omentum or bowel falls away, so that the incision can be readily enlarged by the scissors. If the parietal peritoneum is adherent to the viscera, great care is necessary to avoid injury to the latter, and the adhesions should be separated as the incision is enlarged. Flat sponges or flat pads of gauze are then introduced, so as to hold back the intestines from the field of operation, and if it is expected that pus or fecal matter will enter the field, the gauze must be very carefully placed between the edges of the wound and the organ to be attacked. This having been done, tumors may be removed, abscesses evacuated, or the stomach or intestine opened freely without the danger of exciting peritonitis. After the intra-abdominal work is completed the field of operation must be thoroughly wiped dry, and then the layers of gauze or sponges are removed.

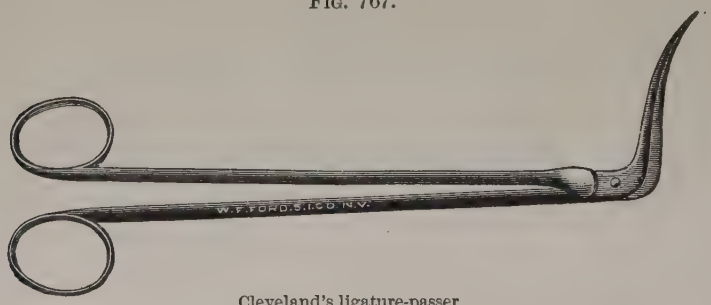
Trendelenburg's Position.—When the patient is placed on an inclined plane, head downward, with the knees flexed, the weight of the body being held by the bent legs and the shoulders being much lower than the hips, the abdominal contents all tend to settle to the upper part of the abdomen, and the pelvic region is emptied of everything except the organs fixed in it. This position is known as Trendelenburg's, and it overcomes the difficulty of preventing loops of intestine from slipping into the field of operation. Before the abdominal wound is closed the patient should be lowered, or in-

testinal obstruction may result from the displaced intestine, and bleeding also may occur after the position is changed.

Peritoneal adhesions are separated with the fingers, and experience is necessary to determine the amount of force which it is safe to employ. If the adhesions are very dense, they may be dissected off with the scissors or the knife, under control of the eye; or, if they are band-like, they may be divided between two clamps or two ligatures.

Treatment of Pedicles.—The pedicles of tumors are tied off by passing double ligatures through them with an aneurism-needle or ligature-passer (Fig. 767), dividing the loop, making the two strands cross, and then tying

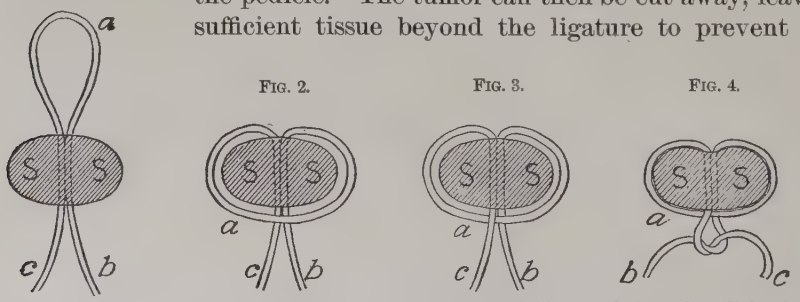
Fig. 767.



Cleveland's ligature-passer.

each pair of ends upon opposite sides of the pedicle. Instead of crossing the ends, after cutting the loop a knot may be tied in the two strands near the middle and the knot then drawn into the centre of the pedicle, when any two ends from opposite sides may be tied without delay. For small tumors Tait's Staffordshire knot is convenient; it is made by leaving the loop of the ligature uncut, slipping it over the tumor and over one of the free ends of the thread, drawing both ends of the thread until the loop is pulled tight around the pedicle, and then tying the ends across the thread of the loop as it lies between them. (Fig. 768.) In a broad, flat pedicle the knot should be tied upon the edge of the pedicle. The tumor can then be cut away, leaving sufficient tissue beyond the ligature to prevent the

Fig. 768.



Staffordshire knot for pedicle: *ss*, section of pedicle; *a*, loop of silk passed through pedicle; *b* and *c*, ends of the ligature to be tied. Fig. 1.—First step,—ligature passed through the pedicle. Fig. 2.—Loop of ligature, *a*, thrown over the tumor so as to surround pedicle and lie upon the ends, *b* and *c*. Fig. 3.—The end *c* drawn through the loop so as to lie over it, *b* remaining under it. Fig. 4.—Loop drawn tightly around pedicle and a single twist or knot taken with ends of ligature. (Byford.)

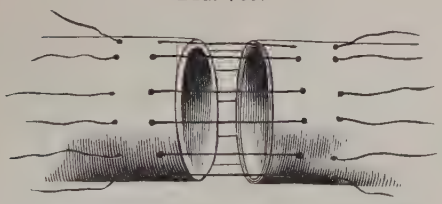
thread from slipping off. In some cases, as in the broad ligament, the pedicle may be too broad and flat to allow of a single ligature, and a number

of ligatures may then be passed, the adjacent loops interlocking; or a cobbler's stitch may be made with a blunt needle on each end of the thread, which is run back and forth through the ligament and the ends tied. In operations upon very vascular organs, such as the uterus and spleen, a temporary ligature, usually of rubber cord, is applied around the pedicle and a bloodless field of operation thus obtained. Care must be taken in passing the ligatures that ureters and other organs are not constricted by them.

Count of Instruments, etc.—The number of instruments and of pads or sponges in use during a laparotomy should be noted before the operation, and they should be counted afterwards, in order to make sure that none are left in the abdominal cavity—an accident which is very likely to occur. It is an excellent plan to have a long tape fastened to each pad or sponge, the tape being left hanging out of the wound when the pad is placed in the abdomen, as it is then less likely to be overlooked.

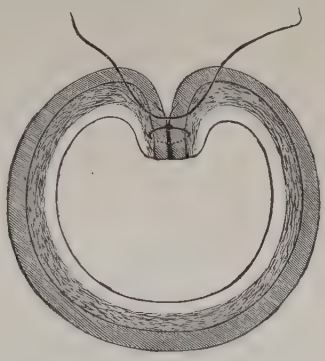
Suture of Stomach and Intestine.—As it has been shown that the peritoneal surfaces unite very rapidly, the best suture for uniting wounds involving this membrane is the Lembert suture (Figs. 769 and 770), which includes only the serous membrane and a little of the subjacent tissue without penetrating the cavity of any hollow organ, and thus brings serous surfaces in apposition. These sutures may be interrupted or continuous, and passed in the ordinary manner or like a quilted suture. (Fig. 771.) In closing wounds of hollow organs a suture should first be made passing entirely through the thickness of their wall in order to hold the parts firmly together, and then the Lembert suture is applied outside, inverting the first tier and covering it over completely. A circular suture of the intestine should always begin at the mesenteric border, and a portion of the mesentery may be resected in order to make nice apposition, but this is seldom necessary. The mesentery must be left attached to the bowel right up to the edge of the wound, or necrosis will result. Whenever the stomach or intestine is opened in a laparotomy its contents should be prevented from escaping by compression by the assistant's fingers, by a strip of gauze tied around it, or by a special clamp, in order to

Fig. 769.



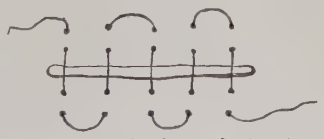
Lembert sutures in circular suture of the intestine. (Agnew.)

Fig. 770.



Section of the intestine through a longitudinal wound united by two tiers of Lembert sutures. (Agnew.)

Fig. 771.



Continuous quilted Lembert suture. (Agnew.)

avoid contamination of the peritoneum. After squeezing the intestinal contents away from the seat of the wound the tape or clamp can be applied at some distance, so as not to interfere with the operation. The intestine or stomach should, if possible, be drawn out of the abdominal wound, which is filled with gauze pads or sponges, and then wounds can be made or treated without danger to the peritoneum.

Drainage.—Much judgment is required to decide whether to drain after a laparotomy. The wound may be closed without drainage if there is no danger of hemorrhage, and if no infectious material has reached the peritoneal cavity. When there is a possibility of hemorrhage after the operation, it is wise to insert a drain, to give prompt warning when the bleeding begins. If pus or fecal material has escaped into the abdomen, even when it has been thoroughly washed out, it is best to drain. If no inflammation follows, the drain may be removed in twenty-four hours, and the opening for it can be closed by a suture, which may be introduced at the time of operation, but left untied. Drainage may be made by rubber or glass tubes, the latter being more easily rendered aseptic, but requiring care to avoid damage by pressure on the bowel. Very excellent capillary drainage is made by rubber tissue loosely rolled into a spiral, or with a core of iodoform gauze. When gauze packing is left in the abdomen the wound must necessarily be left open for its removal, and no drainage-tubes are necessary in such cases.

Closing the abdominal wound is accomplished by sutures of heavy silk or silkworm-gut inserted through the entire thickness of the abdominal wall, about four or five to the inch, care being taken that the edges of the peritoneal surfaces are apposed to each other at the bottom of the wound. A better method is to make a separate suture of the peritoneum, and then pass heavy sutures through all the rest of the abdominal wound without penetrating that membrane, thus shutting off the peritoneal cavity from the possibility of infection by pus collecting along the outer sutures. Another method is to suture each part of the abdominal wall, the peritoneum, the muscular and tendinous structures, and the skin, separately. Catgut may be used for all these sutures, and the sutures may be made continuous. If catgut be used, however, and there is any danger of peritonitis following with the possibility of distention by tympanites, it is well to put in two or three tension sutures of a more lasting material through the entire thickness of the abdominal wall at proper intervals in the wound. Some surgeons prefer a more durable material for the muscular and tendinous layers, and employ buried sutures of silk, silkworm-gut, chromicized catgut, or kangaroo tendon. Buried sutures of permanent material are of no advantage, as they loosen in a few hours, and they are a source of danger, being liable to cause abscesses from latent spores contained in them.

The **after-treatment** of ordinary laparotomy cases consists in rest in bed, low diet, and attention to the bowels. The practice of surgeons differs as to the administration of purgatives, some preferring to give them at once on the least sign of disturbance, and others delaying. Under ordinary circumstances the bowels should be moved by an enema on the second or third day, and sulphate of magnesium may be given if necessary, particularly if there is a rise of temperature, pain, or tympanites. In cases of suture of

the stomach and intestine, however, or of ligation of the stump of the appendix, nothing should be given to excite peristalsis for at least a week, as otherwise the intestinal wound may open. Some surgeons allow patients to get up on the tenth or fourteenth day if primary union of the abdominal wall has taken place. Experiments show, however, that it requires at least three weeks for the new connective tissue to become firm, and if any tension is put on the abdominal walls before that time there is great danger that the new cicatricial tissue will stretch, and a hernia will be produced. When suppuration has taken place in the wound this period should be lengthened, because there is then more cicatricial tissue and more danger of a hernia. For similar reasons the patient should wear an abdominal belt as a support for at least a year after the operation, and the scar should always be watched, so that on the least appearance of hernia a belt or truss may be applied at once. Hernia usually develops, if at all, in the first year.

Extraperitoneal Operations.—Many of the organs in the abdomen, and many inflammatory foci as well, may be reached without opening the peritoneal cavity. The pelvic cavity can be made accessible by incisions parallel to Poupart's ligament, the parietal peritoneum being stripped up as in the old operation for ligature of the iliac artery, and the uterus, bladder, ureter, or other organs reached, or deep collections of pus evacuated, even if they are intraperitoneal, by dividing the peritoneum where they are adherent to it. The kidneys can be removed through incisions in front, somewhat external to the rectus muscles, the peritoneum being stripped up and carrying the large intestine with it until the surface of the kidney comes into view. Extraperitoneal operations are also possible in operating for appendicular abscesses, but are now seldom used. Care is necessary in handling the delicate peritoneum, but rents in it may be easily closed by suture and the operation proceeded with. If pus is to be discharged, the wound should be packed with gauze, as described for intraperitoneal operations, and the question of drainage should be treated on the same principles. The abdominal incision is closed in the usual manner.

DISEASES OF THE ABDOMINAL WALL.

Inflammation.—Ordinary cellulitis of the abdominal wall is not very common, and the surgeon should make certain that it does not arise from some intraperitoneal inflammation. The abdominal wall may be the seat of abscesses as the result of infection, and subcutaneous or muscular gummata are not infrequent in this region, being often mistaken for some form of neoplasm. **Tumors** of the abdominal wall arising from the skin are similar to those in other parts. Subcutaneous **lipoma** and **sebaceous cysts** are frequent. **Sarcoma** is found in the muscles and fascia, but these parts are especially liable to a peculiar form of fibrous tumor called a **desmoid**, which resembles sarcoma, but is less malignant. These tumors form flat masses in the muscles, varying in size from small nodules to the size of the hand and sometimes three or four inches in thickness. It is difficult to distinguish them from sarcoma and from chronic inflammatory conditions, such as gumma. The treatment should be thorough extirpation, as they are liable to return unless completely removed.

THE PERITONEUM.

The peritoneum is a closed serous sac covering the viscera and enabling them to move easily upon each other, and it also has free communication with the lymphatic system. Wounds or ulcers which perforate the hollow organs where they are covered with peritoneum result in peritonitis, but, as the peritoneum does not entirely surround all the abdominal organs, perforations of the extraperitoneal portions of the latter may occur without peritonitis, the cavity of the peritoneum not being invaded. Abscesses usually result in the latter cases. The surface of the peritoneum is nearly as great as that of the external surface of the body, and its absorbing powers are very active, therefore general septic poisoning is easily produced when its cavity contains infectious fluid.

Injuries.—The most important consideration in injuries of the peritoneum is the possibility of septic infection, which may take place from without or from injury of any of the contained organs. The infection may be direct, through a penetrating wound or as a result of sloughing after a severe contusion. In the **repair of wounds** of the peritoneum union takes place most rapidly when the serous surfaces are brought in apposition. Lymph is thrown out between the serous surfaces, the cells proliferate and emigrate into the lymph, and finally the lymph is formed into new connective tissue, the endothelial cells becoming fixed cells. These changes take place very rapidly, and within twenty-four hours the edges are firmly adherent. When a penetrating wound reaches one of the hollow organs or an ulcer threatens to perforate its walls and there is danger of infection of the peritoneal cavity, the irritation of the beginning infection causes the throwing out of lymph and the formation of adhesions around the perforation, which close it in on all sides, and may succeed in limiting it to that portion of the cavity already invaded if the infection is not too virulent. If serious infection takes place in a fresh wound, however, union of the serous surfaces is impeded, and may be entirely prevented, showing that a slight infection causes the formation of adhesions, whereas a virulent one prevents it. **Foreign bodies** may enter the peritoneal cavity by accident, and ligatures are placed there during surgical operations, while sponges and instruments have sometimes been overlooked after operations and left in the cavity. If these bodies are sterile they become encapsulated in the peritoneum by the adhesions which form around them, and large bodies, such as sponges and pads of gauze, have been known to remain in the abdomen for years without symptoms. If they are not aseptic, however, peritonitis may be set up, or an abscess surrounded by adhesions may form. Catgut and such materials are absorbed, provided they are not infected.

Inflammation.—Etiology.—Chemical substances may excite inflammation of the peritoneum, and sterile foreign bodies, such as have been mentioned, may give rise to a low grade of inflammation, which is little more than takes place in repair. Even the intestinal contents, if thoroughly sterilized, fail to set up inflammation when placed in the peritoneal cavity, showing that the bacteria in the feces must be the cause of the peritonitis which invariably follows fecal extravasation. But the normal peritoneum

is able to resist bacteria in pure culture and even in considerable quantity, for it has been shown by experiments that in addition to the bacteria it is necessary that some serum, or blood, or a small quantity of sloughing material in which the germs can grow, should be present in order to excite peritonitis. The presence of foreign bodies also, even if they are in themselves harmless, introduced at the same time as the bacteria, enables the latter to set up peritonitis. If the circulation of the peritoneum is impaired, either in a limited portion by a contusion or in the entire cavity by heart disease or nephritis, for example, the growth of bacteria and consequent peritonitis are favored. The power of the bacteria to excite inflammation appears to reside only in their chemical products or toxines, and it is necessary for the germs to have a growing place where they can produce these toxines before they can excite inflammation. When peritonitis is not set up, the noxious materials are absorbed or encapsulated. The practical conclusions from these facts are important and obvious. Not only must the surgeon's hands, instruments, etc., be sterilized, if he is to operate within the peritoneal cavity without exciting inflammation, but he must be careful to leave no foreign bodies or sloughing tissue in the cavity, and to remove from it all blood and serum, or to provide drainage for the latter. The peritoneum must be protected from strong chemicals and from drying by exposure to the air, for these lower its vitality and impair its resistance to the bacteria.

Pathology.—The first sign of inflammation of the peritoneum is congestion, then lymph is thrown out, the endothelial cells are detached, and the membrane loses its lustre. The endothelia multiply, the fixed cells in the connective-tissue layers also increase, and both assist in providing the wandering cells which penetrate the layers of lymph and form pus when the inflammation is acute. In cases of severe infection serum is thrown out, becoming cloudy as the pus-cells appear. This exudate has a fecal odor if there is a perforation of the bowel, and occasionally even when no perforation exists. If the process does not go so far as to produce pus, the lymph thrown out glues together the serous surfaces which are in contact, forming adhesions (*adhesive peritonitis*). The adhesions disappear when the inflammation ends in resolution, or they become organized into strong connective-tissue layers and bands. If pus is produced (*suppurative peritonitis*), the adhesions formed at the edges of the inflammatory area may completely shut it in and produce *local peritonitis* or *abscess*. Or the adhesions may gradually give way as the inflammation intensifies behind them, and a *progressive suppurative peritonitis* results. In other cases the infection practically begins simultaneously in all parts of the cavity and a *general suppurative peritonitis* follows, but even here many adhesions are present which divide the cavity into numerous spaces, which are not, however, completely shut off from each other. *Intraperitoneal abscesses* may form anywhere in the abdomen as the result of local suppurative peritonitis, and may penetrate the abdominal wall or any of the hollow organs, burrow through the peritoneum and discharge in the groin, or perforate the diaphragm and flood the pleura, or even reach the lung and thus be evacuated. When pus is in the general cavity it is most evident in Douglas's cul-de-sac, which can be felt by rectal or vaginal examination to be distended.

In addition to these forms of inflammation, a *septicæmia* of peritoneal origin may be caused by absorption of the septic products formed in the infected peritoneum. The latter may not react to the infection with the changes and symptoms of inflammation, and the clinical picture is merely that of a profound septicæmia, while the autopsy reveals only slight inflammation and but little exudate in the peritoneal cavity. A *toxæmia* is also caused by absorption of the intestinal contents stagnant by reason of intestinal paralysis.

Symptoms.—The symptoms of peritonitis will vary according as the infection takes place from without or by the perforation of some organ, and these various conditions must therefore be studied separately. **Traumatic Peritonitis.**—An external wound of the peritoneum may be infected at once, or an originally clean wound may become infected, but in either case a strictly localized peritonitis or a local abscess is apt to be the result. The symptoms are a little tenderness in the neighborhood of the wound and some pain, which increase until the abscess bursts through the wound or is discharged by incision. Whenever there is an intraperitoneal abscess, however, there is always danger of subsequent general infection from that source. Traumatic peritonitis may also be caused by wounds of the viscera, and its intensity will depend upon the viscera involved, the most virulent forms following injury to the stomach and intestine, on account of the bacteria in their contents. When the first symptoms of such an injury have passed off and the patient has recovered from the shock, if any infectious material has escaped into the peritoneal cavity from the wounded organ, symptoms of inflammation set in, with abdominal pain, which may be so severe that it cannot be relieved even by large doses of morphine. There is vomiting, the abdomen becomes distended, tympanitic, and rigid, and the temperature rises, usually without a chill. These symptoms may increase, the tympanites growing worse, the vomiting becoming incessant, at first green and then fecal, constipation being absolute, and the patient becoming thoroughly exhausted by the pain and loss of nourishment. But the symptoms which begin so violently may diminish if the infection becomes localized, the tympanites growing less, the vomiting ceasing, and the pain and tenderness becoming limited to one point where the abscess is forming. In other cases the patient may die within twenty-four hours of the acute septic poisoning from absorption of the infectious matter, no active inflammation of the peritoneum having had time to develop. In such a case the patient may present few symptoms—vomiting, pain, and tympanites being absent; but he gradually sinks into a low typhoid condition, with a low grade of fever. In still other cases the inflammation runs a chronic course, being partially localized, but spreading first in one direction and then in another, several abscesses forming in succession, so that the disease may last for many weeks, terminating in death or in recovery. The *prognosis* of traumatic peritonitis is very bad, almost the only chance of recovery being in immediate laparotomy.

A traumatic peritonitis *following laparotomy* shows itself in very acute cases by an immediate rise of temperature and the development of tympanites, with vomiting and constipation, and its course is usually rapidly

fatal. Septic poisoning without inflammation also occurs after laparotomy, and in some cases the condition of intestino-peritoneal septicæmia is set up, in which the patients appear to be poisoned by the decomposing contents of the paralyzed bowel even more than by the exudate in the peritoneum. The autopsy in these cases shows little or no fluid in the peritoneal cavity, but the membrane is reddened and slight adhesions exist, with a little mucoid fluid in the pelvis, the coils of bowel being immensely distended and filled with foul gas and fecal material.

Perforative Peritonitis.—The symptoms of perforative peritonitis vary with the organ from which it originates, and may be preceded by symptoms of disease of that organ. The peritonitis develops rapidly or slowly, and the course and symptoms are not unlike those of traumatic peritonitis. The special varieties will be considered in connection with the various organs.

The Treatment of Suppurative Peritonitis.—Suppurative peritonitis can be treated with success only by surgical measures, for the instances of recovery by spontaneous discharge of the pus are too rare to admit of temporizing methods. During the early stages, before pus has formed, the patient should be kept recumbent and perfectly quiet, the use of the bed-pan being insisted upon lest adhesions be ruptured and the infection spread. An ice-bag or cold coil should be applied to the abdomen and enough morphine given to control vomiting and modify pain, but not enough to mask the symptoms and confuse the diagnosis. Peptonized milk alone should be given for food, and the rectum may be washed out with a small injection of water, but no laxatives should be given.

Whatever the origin of the peritonitis, the operative treatment must depend upon the local or general character of the inflammation. When localized peritonitis results in abscess, the pus should be discharged without exposing any of the uninfected peritoneal surfaces if possible. This can easily be done when adhesions exist between the abscess-cavity and the abdominal wall, by making the incision at that point, as is often the case in abscesses from appendicitis. Pelvic abscesses can also be discharged through incisions in the vagina; but the older method of evacuating them through the rectum is now seldom used, because of the danger of fecal infection of the abscess-cavity.

In the treatment of local peritoneal abscesses it is very important to search for the original cause of the inflammation and remove a gangrenous appendix or a suppurating Fallopian tube or close a perforating ulcer of the stomach or intestine, unless the patient's condition is so bad that these procedures will endanger his life. The incision should be large enough to allow thorough exploration of the cavity with the fingers or by sight. When the abscess has been opened, the pus should be carefully sponged out and the cavity irrigated with sterilized water or 1 to 3000 bichloride solution, which must be sponged out completely afterwards. A large drainage-tube should be inserted at the most dependent part of the cavity and the latter lightly packed with gauze, the external wound being packed also or partly closed with sutures in case it is very large. If it seems probable that asepsis can be established and that suppuration will cease early, sutures may be introduced during the operation, and when the discharge ceases they can be tied

and the wound closed. When it is necessary to invade the uninflamed part of the peritoneum in order to reach the encapsulated pus, the surgeon should pack gauze under the edges of the abdominal wall so as to expose the surface of the inflammatory mass but shut off the general cavity, and the abscess may then be opened and the pus discharged at once. In such cases the gauze packing must be left in place after the operation and the gauze drains inserted into the abscess between its layers. While there is some danger of causing a general peritonitis by this procedure, it is not very great, and it is seldom necessary to delay opening the pus-cavity for twenty-four hours to allow additional adhesions to form, as was once the custom.

When general peritonitis exists, a median incision sufficient to permit introduction of the hand should be made low down, the pus discharged, and the cavity dried out with sponges or sterilized gauze pads as completely as possible. The original cause of the disturbance should be removed if possible, other incisions being made for this purpose if it cannot be readily reached from the median one, as will frequently be the case in general peritonitis arising from appendicitis. All adhesions must be broken down, to discharge the pus which collects between the various loops of bowel and omentum. Particular attention must be paid to the pelvis and to the depressions which exist on each side of the vertebral column in the lumbar region. A long dressing-forceps is introduced through the median wound and passed into the lumbar region on each side, so as to make prominent the abdominal wall just in front of the attachment of the mesocolon, and counter-openings are made by cutting on this from without. Large drainage-tubes are inserted in all the incisions, and the entire cavity flushed with hot sterilized water, the hand being passed back and forth to disseminate the fluid thoroughly and bring out all the pus. The patient should be rolled first on one side and then on the other, in order to discharge as much of the fluid as possible. When there is doubt whether the entire peritoneal cavity is infected, the first incision should be made in the part where it is evident that inflammation exists, and after treatment of this region as if for a localized abscess, small exploratory incisions should be made in the median line or lumbar region, the hands and instruments being sterilized again, so that in case no peritonitis is found there will be no danger of spreading the infection. Vigorous stimulation will be necessary, with elevation of the foot of the bed, and hot bottles placed about the body, in order to overcome the severe shock, these patients being often already exhausted before the operation.

If the patient's temperature is already high at the time of operation, a fall may be expected within a few hours. If, on the other hand, the temperature is low from toxic poisoning, as is seen in some cases of general peritonitis, the operation will be followed by an immediate great elevation of temperature, and this is likely to terminate in death if continued for any length of time. As soon as the shock has been overcome, the heavy dressing should be removed and replaced by two or three layers of gauze laid upon the abdomen, and over this the ice-coil should be applied. Enough morphine is to be given hypodermically to relieve the pain, and no attempt should be made to move the bowels for several days. This is the method

with which we have had the best success; but some surgeons prefer to begin at once with large doses of sulphate of magnesium in order to obtain free movements of the bowels. It has been our experience, however, that this method of treatment increases the vomiting, and that it is usually impossible to get the bowels to move under these circumstances. McCosh has recently reported a series of successful cases treated by the injection of one drachm of a saturated solution of magnesium sulphate into a high loop of the small intestine with a hypodermic syringe during the operation, the puncture being closed by a Lembert suture. There is no objection to attempts at moving the bowels by enemata, but these are rarely successful. Stimulants are generally necessary in large doses to combat the septic poisoning, and the inhalation of oxygen assists this object. The feeding must be carried out with small doses of milk at short intervals, varied by beef extracts and assisted by rectal feeding. Washing out the stomach through the tube will sometimes arrest the vomiting. It will usually be found that the recovery of the patient, if he survives the shock, will depend upon the condition of the stomach, and if the vomiting is not troublesome and the stomach digestion is good he will probably recover.

Gonorrhœal Peritonitis.—Peritonitis from gonorrhœal infection begins in the pelvis, and is almost always a mixed infection. The infectious material finds access to the peritoneum by the Fallopian tubes, through the wall of the bladder, or through the lymphatic vessels of the spermatic cord. The lesions are usually limited to the pelvis, and the disease has a subacute course like pelvic peritonitis, ending in resolution or abscess. The usual treatment is effective, and if an abscess forms, it should be opened.

Tubercular Peritonitis.—Tubercular peritonitis or tuberculosis of the peritoneum shows itself by the formation of adhesions and the production of a fibrinous exudate in the dry form. In the ascitic form large quantities of serum are thrown out, the peritoneum at the same time being thickened. The serous membrane of the parietes and of the various organs is found studded with tubercles, and large tuberculous masses form in the thick fibrinous exudate. These may break down and form abscesses, which may make their way externally or penetrate any of the hollow organs. The disease is secondary to a lesion in some of the abdominal organs, and most frequently in the intestine, from two-thirds to three-quarters of the cases having this origin, while about one-quarter of them arise from the female genitals. This form of tuberculosis is most frequent in early adult life, but occurs at all ages. It is far more common in women than in men, but apparently the majority of the former recover from the disease, as it is more frequently found in men at post-mortem examinations. The symptoms of tuberculosis of the peritoneum are distention of the abdomen, emaciation, fever, ascites, and the formation of masses of exudate in the abdomen. The fever is of the hectic type, and it is not infrequent for a subnormal temperature to last for days at a time in some cases. Palpation reveals great thickening and hardening of the abdominal wall, even when there is great distention. The peritoneal exudate may be so limited as to form solid or cystic tumors, and the omentum is rolled up so as to make a band which can be felt stretching across the abdomen at the navel. Tumors may also be formed

by the enlarged glands behind the peritoneum. The disease progresses slowly, as a rule, and about one-quarter of the well-marked cases end in spontaneous recovery, especially in children.

Treatment.—Medical treatment is of little avail, while surgical methods have succeeded in curing nearly three-quarters of the cases operated upon. Simple tapping in the ascitic form has occasionally resulted in a cure. Aspiration with the injection of sterilized air has been successful in a few cases, and injections of iodoform-glycerin or iodoform oil (ten per cent.) have also been tried with benefit. A simple exploratory laparotomy often results in recovery with the disappearance of the lesions. If abscesses form, they are to be opened, and if any operation is done, the original source of the disease is to be sought for and removed, if possible, the diseased portion of the intestines being resected or the Fallopian tubes removed. There can be no question as to the power which a simple exploratory laparotomy possesses of curing extensive tuberculous peritonitis with universal adhesions, innumerable tubercles, and large masses of exudate, although the manner in which it acts is incomprehensible.

Subphrenic Abscess.—Subphrenic abscesses are intraperitoneal in such a large number of cases that they are best considered together with peritonitis. The abscesses are usually very large, and displace the liver on the right side and the stomach and spleen on the left, forcing the diaphragm upward into the chest to the level of the fourth or third rib. They may cause a secondary empyema, either by directly perforating the diaphragm or, more commonly, by infecting the pleura through the lymphatics. If an empyema forms it may discharge into the bronchi, or if the lung be adherent to the diaphragm the subphrenic abscess may perforate directly into them. The organs of the chest are thus involved secondarily in nearly one-half of the cases. Nearly one-half of these abscesses contain gas in considerable amount, on account of their frequent communication with gas-containing organs. The most common cause of subphrenic abscesses is perforating ulcer of the stomach, but they may arise from suppurative processes in almost any of the abdominal organs, and are not infrequently secondary to appendicitis. The symptoms of these abscesses consist in hectic fever and the evidences of a large tumor succeeding the symptoms of the disease from which they originate.

Diagnosis.—It is important to distinguish between subphrenic abscesses and empyema or abscess of the liver. In empyema the upper surface of the fluid will describe a curved line on the side of the chest, concave upward. In subphrenic abscess the upper limit of the fluid will be convex, the pus being contained beneath the diaphragm. If an aspirating needle is inserted, the flow of the fluid from an empyema will be strongest during expiration, and that from a subphrenic abscess strongest during inspiration, the fluid from the latter being pressed out by the descent of the diaphragm. A similar phenomenon will be observed if gas be contained in the pleural or abscess cavity which the needle enters, as can be demonstrated by placing the end of the needle under water, or holding a lighted match near it. In some cases of subphrenic abscess the aspirating needle has an oscillating movement, owing to the movement of the diaphragm, for it must perforate

that muscle, whereas in empyema the needle is always stationary. Abscess of the liver does not contain gas, its pus is usually sterile, and it generally alters the shape of the liver. The presence of gas in the cavity of these abscesses is demonstrated by the tympanitic percussion-note and by the change in the level of the fluid produced by changing the position of the patient, as in ascites. The prognosis without operation is very bad. About one-half of the cases may be cured by early operation, but usually it is delayed until septic poisoning is present.

Treatment.—Incisions may be made through the abdominal parietes, or if necessary one of the ribs may be resected, as in the operation for opening an abscess of the liver. Abundant drainage must be provided, and when the circumstances of the case and the condition of the patient permit it, a search should be made for the cause, such as perforation of the stomach or duodenum, as proper treatment of such a lesion by suture or otherwise will afford the best protection against septic complications.

Tumors of the Peritoneum.—Tumors may develop in the peritoneal membrane, but usually they are secondary to disease elsewhere, either carcinoma or sarcoma. The primary tumors form small nodular masses, scattered over the surface, and cause a hemorrhagic serous effusion. They are incurable, and are of consequence surgically only because they may be confounded with other conditions. From tuberculosis they are distinguished by their occurrence at a later period in life, by the greater cachexia, and by the blood in the ascitic fluid. Hydatid cysts are also found in the peritoneal cavity, but clinically they cannot be separated from hydatids of the liver, to which they are usually secondary.

LIVER.

Wounds of the liver have been considered with the injuries of the abdomen. The liver is occasionally **displaced**, its ligaments being relaxed so that it may descend even into the lower part of the abdomen, and attempts to secure it in its proper position by suturing it to the abdominal wall have been made with fair success.

Abscess.—Abscesses of the liver may be single or multiple. They may be due to the suppuration of a hæmatoma produced by an injury, or of a hydatid cyst; and they are also caused by gall-stones. Most frequent, however, are the pyæmic and the tropical abscesses. Pyæmic abscesses and those caused by gall-stones are generally multiple. Tropical abscess is usually single and of large size, and is situated in the right lobe in three-quarters of the cases. These abscesses may also occur in cool countries, although not so frequently as in hot, and they are generally secondary to dysentery. They are supposed to be due to infection by the amœba coli.

The pus of liver abscesses is frequently sterile and does not contain bacteria, but this sterile pus when injected experimentally into the rectum of cats has caused proctitis and secondary abscesses of the liver. The single large abscesses most frequently demand surgical attention. They increase very slowly, with vague symptoms, until they attain a considerable size, when septicæmia generally develops, and the diagnosis is rendered possible by the enlargement of the liver and the pain due to distention.

Treatment.—Single abscesses can be treated successfully by operation, but the multiple abscesses are incurable. The abscess may be drained by a large trocar puncture or by free incision. The situation of the pus in the liver is determined by capillary puncture with a fine needle, and when the pus has been found the needle should be left in place and cut down upon at once, in order to avoid the leakage of pus into the peritoneal or the pleural cavity. It may be necessary to pass through the pleural cavity as well as the peritoneum to reach some of these abscesses. When the peritoneal cavity only is to be opened, the incision is made through the abdominal wall, the peritoneum is stitched to the surface of the liver by a complete circle of sutures, and the liver is incised in the centre of this ring. The pus may lie at a depth of two or three inches, and it is best to use the thermo-cautery in making this incision, in order to lessen the hemorrhage. Incisions above the line of the diaphragm may invade the pleura. In this case a portion of one or two ribs is resected, the visceral pleura is stitched down to the diaphragm by a circle of sutures, and the diaphragm is then incised. If the peritoneal cavity is free between the diaphragm and the liver, this is also protected by a circle of sutures before the liver is incised. If haste is not necessary, the liver may be exposed in the wound and the latter packed with gauze for twenty-four hours in order to allow adhesions to form. The after-treatment consists in irrigation of the cavity, and the use of tonics and stimulants. The abscess-cavities are very slow in contracting.

Tumors of the Liver.—It is seldom that tumors of the liver are primary or are recognized early enough to allow of surgical treatment. Keen has collected twenty cases of partial resection of the liver for tumors, however, with a mortality of only ten per cent. ; but the majority of the growths were pedunculated or occupied small pedunculated lobes.

Hydatid Cyst of the Liver is not infrequent, although rare in America. It is formed like hydatids elsewhere, by the implantation of a parasite, which grows into a cyst and forms secondary daughter-cysts. Symptoms are generally absent, on account of its slow growth, until it has attained considerable size. It is said, however, that bile-pigment is very early and constantly found in the urine of these cases, even when the cyst is pedunculated. Attacks of urticaria are also seen. Suppuration of the hydatid causes inflammatory symptoms like those of abscess. Late in the disease hemorrhages take place from the mucous membranes of various organs, and intermittent albuminuria is found. The main symptom, however, is the distention of the liver by the cyst, the organ reaching the navel or the pelvis and forming one or more smooth rounded tumors. Vomiting and cough are frequently caused by the pressure on the vagus, and a caput Medusæ or circle of distended veins forms about the umbilicus. Jaundice is a rare symptom. The tumor may rupture in various directions. If it bursts into the pleura it causes pain in the side and asphyxia, empyema develops, and the pus may perforate the lung ultimately. The lung may be involved directly when it is adherent to the diaphragm before perforation occurs, a pneumonia developing and the contents of the cyst being coughed up when rupture takes place. Rupture into the pericardium is followed by instant death. Rupture into the peritoneum causes sharp pain, followed by peritonitis. In some

cases the cyst ruptures into the gall-ducts, producing an attack of pain like gall-stone colic, followed by jaundice and sometimes by inflammation of the ducts. The cyst may also perforate the stomach, intestines, or urinary organs, when its contents will escape by the natural passages. The **diagnosis** is made by the smooth, globular shape of the cyst, fluctuation being the rule, and sometimes by a peculiar hydatid thrill. This thrill is felt by percussing the tumor in the ordinary way, while an assistant makes the sac tense by the pressure of his hand on its surface near by. The sensation resembles that produced by drawing a wet finger over a thin distended india-rubber bladder. It is rarely simulated by certain abdominal cysts, and we have observed a similar thrill in a case of hydronephrosis. Hydatids also develop between the liver and the diaphragm, and then the diagnosis from pleurisy is not easy. In pleurisy, however, there is an acute onset of pain, with fever and dyspnœa, which are apt to grow less as the fluid exudation develops, unless the latter is very abundant. In echinococcus the onset is chronic, and the pain and dyspnœa continue to increase as the enlargement progresses. In pleurisy there is uniform enlargement of the chest with bulging of the intercostal spaces, but in subphrenic hydatid the lower part of the chest is more enlarged and the intercostal spaces do not change. When the liver is displaced by depression of the diaphragm by pleuritic effusion it is simply pushed down, but the growth of hydatid may change its shape. In pleurisy the line of dulness on percussion on the side of the chest is concave above, but as the hydatid is below the diaphragm the arched outline of the latter is preserved, and the dulness makes a line convex above. Echinococcus may also develop in the pleural cavity, and is to be distinguished from pleurisy by the convex line of dulness and by the fact that the line is unaltered by changes in position. The lung-sounds also are perfectly healthy up to the sharp limit of this line. The shape of the chest in these cases is that of a keg or a barrel, while in subphrenic hydatids it is that of a bell. The liver is more depressed by a pleural hydatid than by one below the diaphragm, because the latter forces the diaphragm upward and paralyzes it so that the respiratory movement of the liver is lost.

Treatment.—The treatment of hydatid cysts depends upon the vitality of the parasite. The entrance of the hydatid poison into the veins may cause instant death, and the entrance of the living parasite may result in secondary growths elsewhere. If the parasite should be alive when the case comes under treatment, therefore, it must first be killed by aspirating the contents of the cyst and injecting a 1 to 1000 bichloride solution, not over one hundred grammes being injected, and the injection being made very slowly. The best method of operation is one similar to that described for abscesses, securing the liver to the chest-wall or to the abdominal wall by sutures, then opening the sac, evacuating it, and draining it. In some cases a living hydatid may be extirpated without previous injection, but this is dangerous on account of the liability to absorption of the fluid. The wall of the sac should be removed if it can be easily detached.

Diseases of the Gall-Bladder and Biliary Ducts.—Inflammation of the gall-bladder and of the ducts may be catarrhal or suppurative. The catarrhal form is not apt to require immediate surgical treatment; but its

results, such as contraction of the gall-bladder, with the formation of strong adhesions to the surrounding parts, cicatricial stricture of the ducts, and the production of gall-stones, may demand operation.

Cholelithiasis.—Gall-stones almost invariably form in the gall-bladder, but in rare cases they may form in the ducts or in the biliary passages of the liver. Their production is the result of obstruction of the biliary passages and inflammation of their mucous membrane, cholesterin and bile-pigment being deposited from the stagnant bile. They vary in size from minute gravel to stones two or three inches in diameter. The common bile-duct will allow the passage of a stone the size of a hazel-nut, and if larger stones than these are passed in the stools they indicate that an unnatural communication has formed between the intestine and the gall-bladder. Gall-stones are usually multiple and facetted on the sides where they are pressed together. They often cause inflammation of the gall-bladder and ducts, and sometimes ulcers, which may perforate and result in intraperitoneal abscesses or abscesses of the liver.

Symptoms.—Gall-stones may exist without symptoms, for they are found in from three to ten per cent. of all cadavers at autopsy, in the great majority of cases having given no symptoms. When they become impacted in the gall-ducts, however, they cause sharp colicky pain in the right side, shooting backward under the scapula, lasting from a few minutes to several hours or days, and sometimes followed by jaundice or by signs of peritoneal inflammation in the neighborhood of the gall-bladder. Jaundice occurs only when impaction takes place in the common duct, and, as the cystic duct is smaller than the common, any stone which can pass the cystic duct should not cause jaundice; but stones sometimes lie in the common duct and increase in size until they are too large to pass into the intestine, when they may cause typical biliary colic and jaundice. The gall-bladder is very frequently not to be felt, and probably it is not distended in all cases. The attack of colic may terminate within a few hours, but there is a liability to a repetition at irregular intervals, and the attacks may be so frequent that the patient is worn out with pain. The stone may slip back into the bladder from the cystic duct, or it may make its way into the bowel and be found in the stool. In rare cases the stone remains impacted, blocking the cystic or the common duct completely. When the cystic duct is obstructed the gall-bladder may distend slowly to a large size, being filled with a clear serous fluid of its own secretion, no bile entering it. This condition is called *hydrops* of the bladder, unless the fluid has become purulent, when it is known as *empyema*. The gall-bladder may also be distended if the cystic duct is obliterated by a cicatricial stricture or tumor. As the gall-bladder enlarges it may draw down a tongue-like lobe of liver-tissue. If the gall-stone remains impacted in the common duct, it may perforate its wall and cause a local abscess, or if adhesions have formed with the intestine the stone may perforate directly into the bowel, and if the stone is very large it may then give rise to intestinal obstruction. The signs of perforation of the bladder and ducts are those of localized peritonitis—pain, tenderness, fever, and the formation of a tumor by adhesions and pus. Pyæmia and metastatic abscesses are also found as a result of cholecystitis.

Tumors of the gall-bladder and ducts are probably not so rare as has been supposed, and a number of cases of small tumors causing obstruction of the duct are on record. They may be recognized by the fact that the gall-bladder is invariably distended, while in gall-stone disease the gall-bladder is more frequently small. Icterus is a much more common symptom than in cases of gall-stones, and there are no attacks of gall-stone colic.

Treatment.—The majority of the cases of gall-stone disease and biliary obstruction can be treated by medical measures, but operation is indicated when the attacks of colic are very frequent and severe, when the jaundice is very marked, and when there are signs of suppurative inflammation in the gall-bladder or its neighborhood. Severe cholæmia is apt to weaken the heart and predispose to hemorrhage, but jaundiced patients, as a rule, bear operations well. The gall-bladder may be exposed by an incision at the right border of the right rectus muscle or by a median incision, but some prefer an oblique incision parallel to the ribs or a vertical incision with a transverse branch on either side in the shape of a ⊢ or an ⌊. The subsequent steps will depend upon the condition found. If a calculus is impacted in the cystic duct, the bladder is to be opened and the stone removed. If this is impossible, the calculus may be crushed by forceps in the duct, or may be broken by padded forceps outside of the duct, or by a needle inserted through the wall, and the fragments abstracted. When the obstruction has been removed, the bladder may be sutured by Lembert sutures if it is healthy and if no obstruction exists in the common duct. If the bladder is diseased, it may be drained by securing the incision in it to the abdominal wound, or it may be extirpated. If the obstruction is a stone which cannot be removed, or a cicatricial stricture or a tumor, the gall-bladder should be extirpated if possible. If extirpation is impossible or very difficult, the alternative is drainage through the abdominal wound, for the creation of a fistula into the intestine (cholecystenterostomy) is not advisable, because the occlusion of the cystic duct shuts off the bladder from the liver and destroys its physiological value, and septic infection of the bladder might be the result of connecting it with the intestine.

If the obstruction is in the common duct, in ordinary cases the bladder can be opened and the calculus removed by pushing it back into the bladder through the cystic duct, by crushing it with forceps, or by breaking it up with the needle. If the stone is removed, the bladder may then be sutured and returned to the abdomen, or it may be secured in the abdominal wound and drained, or it may be extirpated, the first being the method of choice. Should the obstruction be irremediable (impacted calculus, tumor), the bladder may be drained either by making a fistula into the intestine, or externally, or the bladder may be sutured and the dilated duct connected with the intestine by a fistula. In some cases of obstruction in the common duct the gall-bladder is found greatly contracted or absent: the common duct should then be incised and the obstruction removed, the incision being sutured, or drained when suture is impossible. If the obstruction is found irremediable the incised duct must be drained. This drainage may be established by making a fistula between the duct and the bowel, or by inserting a tube in the duct and bringing it out of the abdominal wound, or, finally,

the omentum may be arranged so as to make a funnel-shaped cavity around the wound in the duct, which is lightly packed with gauze. In such cases, if there should prove to be serious disease of the bladder, ulceration, abscess, or tumor, the organ should be extirpated.

McBurney has successfully removed a calculus from the common duct by incising the duodenum and stretching or incising the intestinal orifice of the duct, and we have adopted a similar treatment in a case of a small tumor of the duodenum obstructing the duct, in which the tumor was in the duodenal mucous membrane close to the papilla. Finally, in cases of tumor of the gall-bladder, or hydrops, or empyema, the organ should be extirpated if possible; but if the adhesions are very strong, hydrops and empyema may be treated by drainage in the abdominal wound. Cholecystenterostomy should never be performed in these cases.

The various methods of opening and draining the bladder and duct may be formulated as follows:

1. **Cholecystotomy.**—The bladder may be incised immediately after protecting the peritoneal cavity with gauze or sponges. When the stone has been removed the bladder may be drained or sutured.

2. **Cholecystostomy** consists in securing the bladder in the wound after it has been opened, the edges of the incision in the bladder being sutured to the edges of the abdominal wound. The abdominal wound should be sutured, except at one angle, where the peritoneum and skin of each edge should be united for a distance of about an inch, and the peritoneal surface of the gall-bladder stitched to this opening. It was formerly considered dangerous to open the bladder in the free peritoneal cavity, and it was therefore sutured in the abdominal wound, or gauze was packed down in the abdominal wound, and a delay of from twenty-four to forty-eight hours was made in order to allow adhesions to form, and then the bladder was opened; but this operation in two acts is now seldom considered necessary.

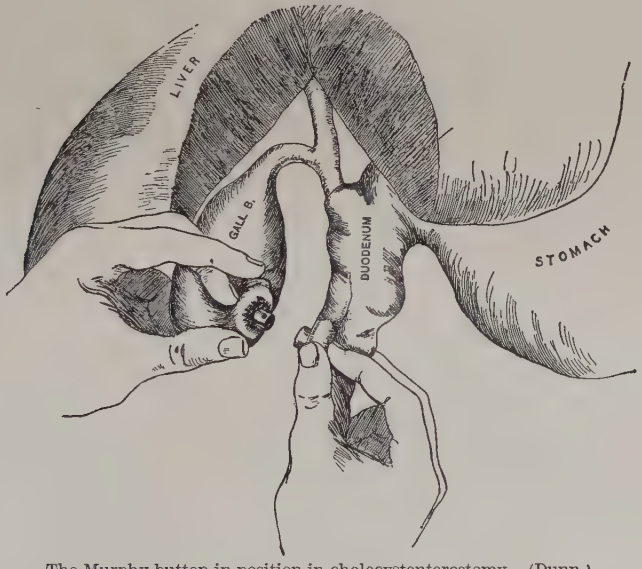
3. **Cholecystendyse.**—When the bladder is healthy, and there is no obstruction in the biliary passages, it is possible to suture the organ and drop it back into the abdomen. This proceeding, also called "ideal cholecystotomy," has the great advantage of securing primary union of the entire wound and saving the patient from the liability of a permanent and annoying fistula, for in about one-fifth of the cases cholecystostomy is followed by a fistula discharging bile and mucus. The suturing of the bladder, while suitable for only comparatively simple cases, appears to be a safe procedure, the mortality being even less than in cholecystostomy.

4. **Cholecystectomy.**—Extirpation of the gall-bladder was first suggested because gall-stones are formed in that organ, and it was supposed that its removal would effect a permanent cure. It is true that stones are formed in the ducts and in the liver also, but this occurs so rarely that it need scarcely be taken into account. On the other hand, relapses after the ordinary methods of treatment are certainly not common, and the removal of the gall-bladder adds to the danger of the operation. But if the gall-bladder is the seat of diffuse suppuration, a deep ulcer, or a tumor, it is desirable that it should be removed. The operation is done by dissecting the organ free with the finger, for it is usually very adherent in these cases, then

ligating the cystic duct and cutting away the organ. The mucous membrane of the stump is to be destroyed by cauterization. Partial removal of the gall-bladder is an excellent method of treating cases in which the ulcer or the tumor is limited to the fundus.

5. **Cholecystenterostomy.**—When there is a permanent obstruction in the common duct it is absolutely necessary to secure an outlet for the bile, which may be accomplished by making a permanent external fistula by cholecystostomy, but to avoid the loss of the bile it is preferable to make an opening between the gall-bladder and the bowel, as high up as possible. This may be done after the manner of a gastro-enterostomy by suturing the edges of a small incision in the gall-bladder to a similar incision in the loop of jejunum chosen. But a better method is the use of the Murphy button, the insertion of which will be described with gastro-enterostomy, page 943. (Fig. 772.) The operation by suture has had a mortality of thirty per

FIG. 772.



The Murphy button in position in cholecystenterostomy. (Dunn.)

cent., whereas Murphy has collected forty-seven cases in which the button was used, with only two deaths. There are, however, two objections to the Murphy button: first, that the opening is very small and circular and may contract—obliteration having been known to take place in less than six months; secondly, that the button may slip back into the gall-bladder when it becomes detached, instead of falling into the intestine, and may there form a foreign body. The first objection can hardly be met, but the second might possibly be prevented by making the intestinal half of the button larger than that in the gall-bladder, as suggested by Lilienthal.

6. **Choledochotomy** is the making of an opening in the common duct. When this is sutured we speak of choledochendyse. When it is connected with the intestine we speak of a choledochenterostomy. The depth at which the common duct lies makes operations upon it exceedingly difficult in the

majority of cases, yet it is often possible to suture the wound in that duct or to unite it with the duodenum, the duct being, as a rule, greatly dilated, even to the size of the thumb, in cases where these operations are necessary. It can be made more accessible by placing a pillow under the patient's loins and allowing the shoulders and pelvis to fall backward.

SURGICAL DISEASES OF THE STOMACH.

Topography.—The position of the stomach as usually represented is not quite correct, its true situation being much more nearly that known as the "fœtal position;" that is to say, the long axis is nearly vertical, its lesser curvature being directed towards the right side of the body and the greater curvature towards the left. When the stomach is distended the greater curvature becomes very much larger, and forms a pouch extending upward under the diaphragm and downward below the level of the pylorus. The pylorus lies above the lowest part of this pouch, making with the duodenum an ∾ trap. As a result of chronic dilatation, the position of the stomach may be materially altered, the attachments of the pylorus giving way, and that valve being carried downward as low as the iliac region. In other cases the pylorus retains its position, and the pouch of the stomach descends even below the umbilicus. The pylorus in the empty condition of the organ is situated just under the border of the ribs and the liver, a trifle to the right of the middle line. When the stomach is distended the pylorus moves to the right and slightly downward, reaching a point midway between the median line and the nipple-line.

Foreign Bodies.—Foreign bodies may enter the stomach, persons of weak minds frequently swallowing such articles as jack-knives and spoons, and hysterical women being known to swallow hair, which forms a ball in the stomach similar to the hair-balls so often found in cattle, due in the latter to the constant licking of their coats. These foreign bodies may be retained for a long time without discomfort, but they are apt to produce ulceration by pressure upon some part of the stomach-wall, or to become lodged in the pylorus and obstruct that opening. Such bodies can easily be removed by the operation of gastrotomy, and this should be performed at once in case they are too large to pass through the bowel.

Inflammation.—Ulcer.—The inflammations of the stomach which interest the surgeon are those which produce gastric ulcer and chronic thickening of the muscular coats in the neighborhood of the pylorus. Ulcer of the stomach is apt to result in hemorrhage or peritonitis from perforation, and surgical treatment by excision of the ulcer has been attempted before the occurrence of these accidents, but not very successfully as yet, because it is difficult to recognize the situation of the ulcer. The ulcer is usually situated on the anterior wall, and very often near the lesser curvature.

Symptoms and Diagnosis.—The majority of the patients are women about twenty-five years of age, and are household servants. The symptoms of gastric ulcer are intense localized pain in the stomach, increased by the presence of food; vomiting, particularly the vomiting of bright blood; loss of digestive power; and anæmia. Perforation into the peritoneal cavity may take place without any previous symptoms of gastric trouble, in eight per

cent. of the cases according to Weir and Foote, but, as a rule, there are sufficient symptoms to make a diagnosis possible. When the gastric symptoms are clear and the patient feels a sudden acute pain in the epigastrium, often associated with severe collapse, with or without vomiting, which is followed by local tenderness, rise of temperature, and the development of tympanites, a correct diagnosis is easy. Vomiting is present in about two-thirds of the cases of perforation. The dulness on percussion over the liver may be lost, owing to the escape of gas into the peritoneal cavity. (See page 930.) The pain, however, may first be felt in any other part of the abdomen, and even the tenderness may be more marked in the iliac region than in the epigastrium. Occasionally profound septic poisoning accompanies very mild local symptoms, but, as a rule, perforation of the stomach produces a frank general peritonitis or a localized abscess, and peritoneal sepsis occurs less frequently than after intestinal perforation. The perforation may take place in that part of the stomach not covered by peritoneum, and an extraperitoneal abscess may form under the diaphragm or between the diaphragm and the liver. These cases naturally run a slower course, and if the diagnosis can be made before septicæmia sets in, a cure may be expected. A few cases of perforation of the stomach have recovered without operation. The prognosis after operation depends altogether upon the interval of time which elapses between the perforation and the laparotomy. Weir has shown that when the operation was done within twelve hours the majority of the cases were saved, but in later operations only about one-fifth recovered.

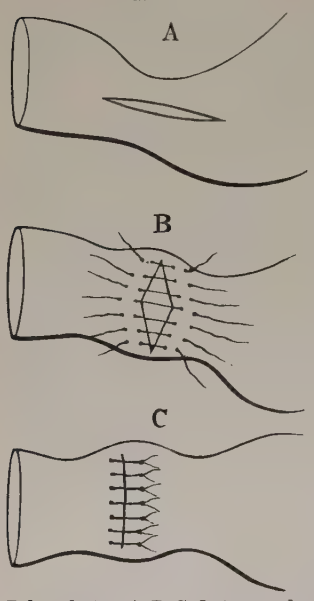
Treatment.—A median incision is made above the navel, and a transverse incision at right angles to the first through the left rectus muscle may be added later if necessary in order to obtain sufficient room. The stomach must be well drawn down, as the perforation will usually be found high up on the lesser curvature. The posterior wall may be examined by tearing through the mesocolon. When the perforation is found, it should be closed with Lembert sutures. It is unnecessary to excise the edges of the ulcer, and the condition of the patient rarely allows a prolonged operation. The abscess must be thoroughly washed out and drained, and if general peritonitis is present it must be treated as already described.

Stenosis of the Pylorus.—Narrowing of the pylorus may be caused by external compression, by cicatricial contraction due to healed ulcers on the inner surface, or by the growth of tumors in the stomach-wall at this point. It is said that there may also be a spasmodic contraction of the sphincter muscle. Mechanical dilatation of the stomach often results in these cases, but in malignant disease this dilatation seldom occurs, because of the short duration of life. The symptoms of simple stenosis of the pylorus are merely those of obstruction, as shown by vomiting, usually coming on some little time after a meal, and occasionally recurring at regular intervals of two or three days. The ejected matter consists of food, and sometimes contains undigested particles of food taken several days previously. The vomiting is preceded by signs of discomfort and fulness in the stomach, but there is no nausea, and the patient looks upon it as a relief.

The **treatment** of pyloric stricture depends upon the cause of the narrowing. **Loreta's method** consists in stretching the pylorus by performing

a laparotomy, invaginating the stomach-wall with the finger, and forcing the latter through the sphincter. The immediate effects of this operation were excellent, but subsequent contraction took place in the great majority of cases. Heineke and Mikulicz introduced an operation known as **pyloroplasty,** which is useful when the stomach-walls are thin and the duodenum and stomach can be brought easily in contact. Pyloroplasty is performed by incising the pylorus in the direction of its longitudinal fibres (Fig. 773, A), pulling the edges of this incision apart (B) and uniting them in an opposite direction (C), so that the two ends of the longitudinal incision are united in the centre, and the middle points of its upper and lower lips become the upper and lower angles of the wound when sutured, the longitudinal incision thus being converted into a transverse one. For cases in which there is a tumor or limited inflammatory thickening of the wall of the stomach and pylorus, a resection of the parts gives excellent results. For all other cases a gastro-enterostomy is the best method of treatment.

Fig. 773.



Pyloroplasty: A, B, C, first, second, and third stages.

Dilatation of the stomach, whether it is caused by mechanical obstruction at the pylorus or not, may be treated surgically by doing a laparotomy, folding a long strip of the anterior wall of the stomach into the interior of the organ, and securing it in that position by a series of sutures.

In some rare cases the condition known as **hour-glass contraction of the stomach** exists as the result of cicatricial contraction of a circular ulceration in the centre of the organ, so that the cardiac and pyloric portions of the stomach are separated by a narrow stricture, barely admitting the finger. For the relief of this condition an operation similar to pyloroplasty may be done, but Wölffler recommends making an anastomotic opening between the two parts of the stomach.

Tumors.—Benign tumors of the stomach are mere curiosities on account of their rarity, but a chronic inflammation in the neighborhood of the pylorus may produce such thickening of the stomach-wall in that situation as to simulate a cancer. This fibrous deposit may make the wall of the stomach over half an inch in thickness, and may interfere with the movements of the pylorus by its rigidity and produce obstruction. The diagnosis may be very difficult, even when the new tissue has been cut into and inspected. If its benign nature appears certain it is unnecessary to remove the pylorus, as a gastro-enterostomy will relieve the symptoms, but in cases of doubt it is better to resect that part. Cicatricial thickening of the pylorus may also simulate malignant disease. The malignant tumors of the stomach are sarcoma and carcinoma.

Sarcoma.—Only a few cases of sarcoma have been observed, but this disease may be suspected whenever the tumor reaches a considerable size without affecting the general health, is situated on the greater curvature and not near the pylorus, and occurs in comparatively young individuals.

Carcinoma.—Carcinoma is most frequently situated in the neighborhood of the pylorus, where even a small tumor may produce obstruction. Ulceration occurs, and may cause death by hemorrhage. The disease involves the glands comparatively early, and forms metastases in the liver later.

Symptoms and Diagnosis.—The principal symptoms of cancer of the stomach are the presence of a tumor, with obstructive vomiting, the vomiting taking place some little time after eating, and occasionally at regular intervals, and the vomited matter containing undigested particles of food eaten hours or days previously. Pain may or may not be present. There may be in the later stages vomiting of a coffee-ground matter, which is the remains of partially digested blood. In order to obtain a cure by operation the diagnosis must be made very early in the disease; and yet this is exceedingly difficult, because secondary infection occurs while the tumor is still small and out of reach under the ribs, and because pain and vomiting may not occur until the disease is well advanced. The tumor in cancer of the pylorus when first discovered usually feels about the size of a small hen's egg and is more or less fixed, but it can sometimes be moved through a considerable area, being more readily pushed up than drawn down. The surface may be nodular or smooth. Hydrochloric acid, which is a natural constituent of the contents of the stomach, is diminished or absent in cancer, but this sign is not invariable, and it is also found in other diseases. The presence of lactic acid in the stomach, associated with the absence of hydrochloric acid, adds to the certainty of the diagnosis. To ascertain these facts, "test-meals" of certain foods are given and the contents obtained by the stomach-tube for analysis. Ulcer of the stomach resembles cancer in some of its symptoms, but, as a rule, the diagnosis can be made by the fact that the patient with ulcer is usually under forty years of age, by the presence of acute pain, by the absence of obstructive vomiting—the vomiting being of an irritable type and taking place immediately after eating—and by the occurrence of bright blood instead of coffee-ground material in the vomited matter. There will also be tenderness over the stomach and an absence of tumor, unless perforation has taken place and produced an inflammatory mass of omentum and adhesions. It is possible that the examination of the stomach by a minute electric lamp, which is passed down on an œsophageal bougie so that the light shall shine through the abdominal wall, as recently recommended, may be of use in the diagnosis of tumors of the stomach, but as yet no progress has been made in this direction.

Treatment.—As between gastro-enterostomy and resection in obstruction of the pylorus, the former is at present the favorite operation. The mortality from resection is very high, being over fifty per cent., although in the hands of the best operators it has been steadily reduced. The mortality from gastro-enterostomy is reasonably low, a large number of the deaths being attributable to the weak condition of the patient at the time. In benign obstruction of the pylorus a resection gives a permanent cure with a

perfectly normal relation of the parts, and is, therefore, to be preferred to a gastro-enterostomy. In cases of malignant disease, however, very few of the patients have survived resection and remained without recurrence, so that gastro-enterostomy offers as much hope of prolonging life, since it relieves the obstruction, which is the most urgent symptom of the disease, as well as resection. In cancer of the pylorus, therefore, resection should be strictly limited to tumors having no sign of secondary disease in the glands.

Operations.—Gastrotomy is the simple incision of the stomach for the removal of a foreign body or for exploration of its interior, and is performed by doing a median laparotomy and making an incision on the anterior surface of the stomach parallel with the greater curvature, but sufficiently far away from it to avoid the arterial branches. The incision is closed by three tiers of sutures, the first through the mucous membrane, the second suturing the muscle, which is very thick, and the third drawing the serous coat together over the wound.

Gastrostomy.—In cases of stricture of the œsophagus a permanent opening may be made in the stomach for the introduction of food and the prolongation of life, and this operation is called gastrostomy. The simplest method of its performance is to make a small oblique incision through the abdominal wall, parallel to the ribs and a finger's breadth distant from them. The peritoneum is sutured to the skin around this opening. The anterior wall of the stomach is picked up and two stout loops of silk passed in the thickness of the wall, but not entirely through it, within half an inch of each other. While an assistant holds the stomach in the wound by these loops the peritoneal coat of the stomach is sutured to the serous membrane of the abdominal wall. The stomach is allowed to form adhesions to the abdominal wall before it is incised, the opening being delayed for twenty-four hours, if the patient's condition allows. Hahn makes an incision over the eighth intercostal space on the left side, opens the peritoneum, draws a loop of the stomach through this space, and sutures it to the edge of the incision The great objection to the simple method of gastrostomy is the difficulty of closing the opening in the stomach by a pad, resulting in irritation of the skin in the neighborhood by the gastric juice. Hahn's method aims to overcome this by making the opening in the stomach in the centre of a bony framework which furnishes a support for the pad.

A still better method of forming a fistula is that devised by Witzel. The ordinary incision is made through the rectus muscle, and the stomach is drawn out and a minute opening made in it. A small catheter, No. 15 F., is passed into this opening, and a fold of the wall of the stomach is drawn over the catheter on each side as it lies against the stomach-wall, the folds being secured by two or three sutures. (Figs. 774, 775, 776.) The stomach is then fixed in the abdominal wound by sutures in the usual way, closing it around the catheter as tightly as possible. The intention of this operation is to produce an oblique canal by the folding of the stomach-wall around the catheter, so that when the stomach is distended the pressure within will close the canal by valvular action. The results obtained by this method are excellent, the only objections to it being that it necessitates opening of the stomach at the time of operation and exposing the peritoneal

cavity, and that its performance requires somewhat more time than the ordinary operation, the condition of many of these patients being so critical that a tedious operation is a serious drawback. We have, however, succeeded in performing it under cocaine anæsthesia with perfectly satisfactory results, and the length of the operation is then of less importance. The catheter is removed at the end of a week, and is then introduced only at the time of feeding. The leakage from the sinus is very slight and is easily absorbed by a dressing, no pad being required.

Gastro-enterostomy consists in making an opening between the stomach and the intestine, and is employed in cases where there is great pyloric obstruction. It may be performed by Murphy's button or by suture, and on the anterior or the posterior wall.

FIG. 774.

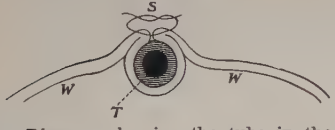
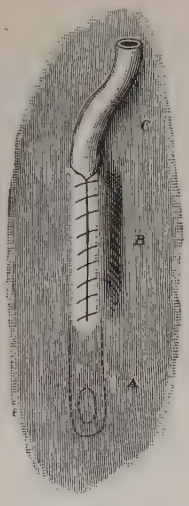


Diagram showing the tube in the fold in the wall of the stomach: *T*, cross-section of the tube; *W*, *W*, wall of the stomach folded over the tube, and about to be retained by tightening the stitch *S*. (Andrews.)

FIG. 775.



Showing the tube in position: *A*, the part inside of the stomach, indicated by dotted lines; *B*, the part surrounded by the folds of the stomach-wall; *C*, the part outside the stomach. (Andrews.)

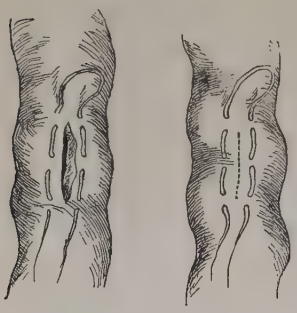
FIG. 776.

Diagram of the course of the tube in the stomach-walls: *I*, the internal orifice of the new canal; *E*, the point of emergence from the surrounding stomach-wall; *P*, a conical plug in the outer end of the tube. (Andrews.)

Operation with Murphy's Button.—The stomach is exposed by a median incision, or by an incision through the left rectus muscle, or at the outer border of the latter. When the stomach is very much retracted it may be necessary to add to this a transverse incision in either direction, according to circumstances. The stomach is found and drawn into the wound, a point being selected upon its anterior surface free from blood-vessels and from disease. A loop of small intestine is drawn up in the lower angle of the wound and a point selected about three feet from the beginning of the jejunum, the intervening loop being left in order to turn around the transverse colon. It is important to recognize the exact situation of the point selected for the anastomosis, for if the opening is made too far down in the intestine the result may be disastrous from lack of nutrition. A loop of bowel, from six to twelve inches long, is isolated by two strips of gauze tied around the gut at each end, the contents of the loop

being squeezed out thoroughly before the gauze strips are tied. A small incision is then made in the stomach while an assistant compresses the organ with his fingers so that none of its contents shall escape. A straight needle armed with stout silk is passed so as to make a continuous suture, including the entire thickness of the stomach-wall and circumscribing this opening close to its edge, or this suture may be placed before the incision is made. (Fig. 777.) One-half of the Murphy button is then slipped into the incision, and the thread adjusted so as to draw the edges tightly around the stem of the button, and tied. A similar incision is made in the bowel

Fig. 777.



Application of sutures for the use of the Murphy button. (Dunn.)

Fig. 778.

Murphy button inserted and ready to be joined in intestinal anastomosis. (After Von Frey.)

on the side away from the mesenteric border, and the other half of the button inserted after passing a purse-string suture around the edges, as before. (Fig. 778.) The two halves of the button are then pressed firmly together, the bowel being placed so that the direction of its peristalsis is the same as that of the stomach, and, finally, a Lembert continuous suture of fine silk is run around the opening in order to make it perfectly secure. The gauze strips are removed from the loop of bowel, the organs replaced, and the abdominal wound closed.

Operation by Suture.—The steps of the operation by suture are the same up to the exposure of the stomach and the isolation of the loop of bowel. The latter is held in proper position close to the stomach at the point chosen for the opening, and a continuous Lembert suture at that point, more than two inches in length, holds the two in position. With a sharp knife an incision two inches long is made through the serous and muscular coats of the stomach and of the gut, and the edges on the side near the line of suture are united by a second continuous stitch. The mucous membrane is then divided for the same distance, and a continuous suture of fine silk secures the edges of the gastric mucous membrane to that of the intestine, first on the distal side of the opening and then on the proximal. The muscular coats of the two organs are then united on the proximal side of the organ, and, finally, the Lembert sutures of the serous surface are continued completely around the opening.

Posterior Operation.—Von Hacker has recommended making the opening in the posterior wall of the stomach, in order to avoid bringing the small intestine in a loop around the transverse colon. In this method, after

the stomach has been exposed, the transverse colon is drawn out of the abdominal wound, thrown upward over the chest, and covered with a warm, moist towel. The operator then selects a portion of the mesocolon where it covers the posterior wall of the stomach which is free from blood-vessels, and tears an opening in this about three inches in diameter, exposing the stomach. The edges of the torn peritoneum are secured to the stomach-wall with two or three sutures. The bowel is united to the stomach by button or suture, as already described. This method has the further advantage of lessening the liability to vomiting, because as the patient lies on the back the food passes backward by gravity into the intestine through the opening in the posterior wall of the stomach.

Resection.—**Resection of the stomach-wall,** not including the pylorus, is a comparatively easy procedure, the tumor being cut away freely, the vessels caught and ligated in the usual way, and the wound closed with a three-tier suture, mucous membrane, muscular, and serous, either continuous or interrupted, of fine silk. The part of the stomach-wall removed should be elliptical in shape, and the long axis may be placed either longitudinally or transversely. Very large portions of the stomach have been removed without apparent injury to digestion.

Pylorectomy.—Resection of the stomach-wall, however, will usually include the pylorus as well. The technique of the latter operation is as follows. After exposure of the stomach, a careful examination of the neighborhood of the pylorus should be made in cases of malignant disease, to ascertain whether there are infected glands. If there is no contra-indication to resection, the pylorus and tumor are completely isolated by a series of double ligatures passed through the mesentery above and below. An assistant shuts off the pylorus from the rest of the stomach by pressure with the fingers, while another assistant compresses the duodenum, a long, narrow clamp is placed on each side of the portion to be removed, and the latter is excised between these clamps and the assistants' fingers. The clamps and tumor being removed, the edges of the circular incisions are united. On the posterior wall the serous layers must first be brought in contact, then the muscular layers, and finally the mucous layer, all sutures being tied on the inside. Interrupted sutures of fine silk are generally used, although some surgeons employ catgut and a continuous stitch. The mucous membrane suture is then continued on the anterior side of the wound, completing the circle, followed by completion of the suturing of the muscular and serous layers. The bowel and stomach are then released and the abdominal wound closed. If the line of resection through the stomach passes some distance from the pylorus, or if the removal of the diseased tissues requires an oblique incision of the stomach-wall, the opening in the stomach will be much larger than that in the duodenum, and before the circular suture described is made, the opening in the stomach should be reduced by sutures until it is of proper size to unite with the duodenum.

Combined Resection and Gastro-Enterostomy.—In cases of extensive resection, and even in ordinary cases, it is often easier to invaginate the cut ends of the stomach and duodenum and close them entirely by a double row of stitches, the first including the entire thickness, and the second the

serous coat only. The remaining portion of the stomach is then united to the jejunum, as in the ordinary operation for gastro-enterostomy. The results of this method are far better than those of circular suture.

Gastric Fistula.—It may be necessary to close a gastric fistula which has been produced by the external opening of abscesses communicating with the organ, by accidental injuries, or by operation. If the fistula is small or made by the Witzel method, it may close spontaneously. To close it by operation the abdomen must be opened, the stomach freed, the edges of the opening in the latter inverted and sutured, and the abdominal wound closed after cutting away its edges until healthy tissues are reached.

Feeding after Operations on the Stomach.—Before any operation upon the stomach is performed, the organ should be thoroughly washed out with the tube. In the after-treatment of these cases feeding by the mouth is suspended and rectal alimentation employed for forty-eight hours. There is seldom any vomiting in resuming feeding by the mouth, provided the food be given in small quantities at first and limited to sterilized milk or peptonized milk and water. Solid food may be given in ten days.

DISEASES OF THE INTESTINES.

Foreign Bodies.—Foreign bodies which have been swallowed may lodge in the intestines, as well as large gall-stones or concretions of inspissated feces. Forks, knives, spoons, and tooth-brushes have been removed by operation either directly from the intestine or from abscesses which had formed by their perforation of the bowel. When small sharp objects have been swallowed, such as nails or pins, the best treatment is to feed the patient on large quantities of some food which will make bulky feces and form a bolus around the object and carry it safely through the canal without danger of perforation, potato being the best material for this purpose. Intubation tubes are often swallowed, but usually pass without trouble. The larger foreign bodies, gall-stones, and concretions may give rise to intestinal obstruction, or may perforate the intestinal wall and cause peritonitis, either local or general. If an abscess is formed, the foreign body may make its way through the abdominal wall spontaneously and recovery ensue. As soon as the presence of these objects is known they should be removed from the bowel by laparotomy and incision.

Inflammation. Ulcer. Stricture.—Ulceration of the bowel occurs in typhoid fever and dysentery, and may result in perforation followed by local or general peritonitis. Tubercular inflammation may cause perforation or may form solid tumors made up of the thickened wall of the bowel and of the peritoneal adhesions. When ulcers of the bowel heal, a stricture may be produced by cicatricial contraction or by surrounding adhesions, and this occurs most frequently in the neighborhood of the ileo-cæcal valve as a result of typhoid fever or of tuberculosis. These strictures produce intestinal obstruction, usually of a rather chronic type, which can be relieved by such operations as making an artificial anus, removing the diseased loop of bowel and uniting its ends, or making an intestinal anastomosis by uniting a loop of the bowel above to one below the point of stricture, so that the contents of the bowel may descend without passing through the narrowed portion.

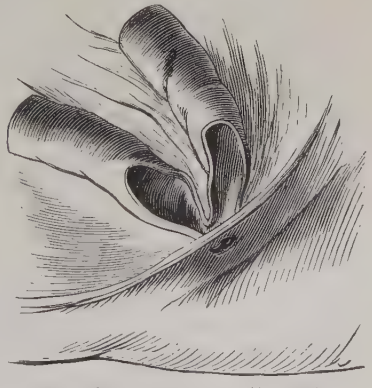
Tumors.—The benign tumors of the bowel are usually polypoid. They may be adenomata, growing from the mucous membrane, or fibromata, originating from the submucous coat. Polypi are occasionally multiple, and occur in any part of the bowel. If large, they may cause obstruction, and even a small polypus, by dragging on the wall of the bowel during peristalsis, may form an intussusception. If they are recognized, they should be removed, with thorough excision of the base from which they grow.

Sarcoma is rare, but occurs in both the large and the small intestine, although more frequently in the latter. It is found in young persons, forming tumors of considerable size, running a rather rapid course, and resulting in intestinal obstruction, cachexia, and death. A very early operation may offer some hope of cure, but the diagnosis is difficult in this stage.

Carcinoma of the bowel is most common in the neighborhood of the ileo-cæcal valve, at the flexures of the colon, and in the sigmoid. It occurs in elderly persons and in two forms. In one variety the tumor is large, making a considerable mass, which becomes adherent to the surrounding parts, but may not greatly obstruct the calibre of the bowel. In the other form the mass is very small, and when the bowel is exposed no tumor may be seen, the intestine looking as though a string had been tied around it, but on compressing the bowel between the fingers a small hard mass is felt. The diseased wall of the gut is found on section to be thickened circularly, greatly reducing the calibre of the bowel. These tumors are of slow growth, and do not involve the glands early. In both forms the symptoms are those of chronic constipation, ending in intestinal obstruction. There may be intermittent diarrhœa and discharge of pus and blood. Pain may be present, with colicky exacerbations. Cachexia finally sets in, and death occurs about two years after the first symptoms, and sometimes sooner. If an early diagnosis can be made before the glands are infected, the tumor may be excised. After that time the obstruction may be relieved by making an intestinal anastomosis or an artificial anus.

Fecal Fistula.—A fecal fistula is an opening between the bowel and the external parts or some of the hollow viscera, such as the vagina or the bladder, or another loop of intestine. These openings are the result of accidental wounds, of inflammation with sloughing, and of ligatures applied in laparotomies, but most frequently of strangulated herniæ, with sloughing of the bowel and sac. The internal variety usually requires some plastic operation in the vagina, or an extensive laparotomy with suture of both the intestine and the other organ involved. In the external fistulæ, unless the opening is large, there is a strong tendency to spontaneous cure by cicatricial contraction, although the process is a slow one. The main obstacle to closure is the existence of a bend in the bowel at the point of the fistula, so that the afferent

Fig. 779.



Fecal fistula with spur. (Agnew.)

and efferent loops lie side by side, with a spur between them which prevents the contents of the afferent loop from passing directly into the efferent, and forces them to issue by the fistula. (Fig. 779.) The worst cases are those seen after strangulated hernia, as a complete loop of bowel usually sloughs in such cases, leaving two openings into the ends of the gut as they lie side by side. (Fig. 780.) When the bowel is opened by an abscess which has eroded its wall, a lateral opening results (Fig. 781),

Fig. 780.

"Double-barrelled" fecal fistula after hernia. (The dotted lines show the position of the loop which has sloughed.) (Agnew.)

Fig. 781.

Lateral fecal fistula. (Agnew.)

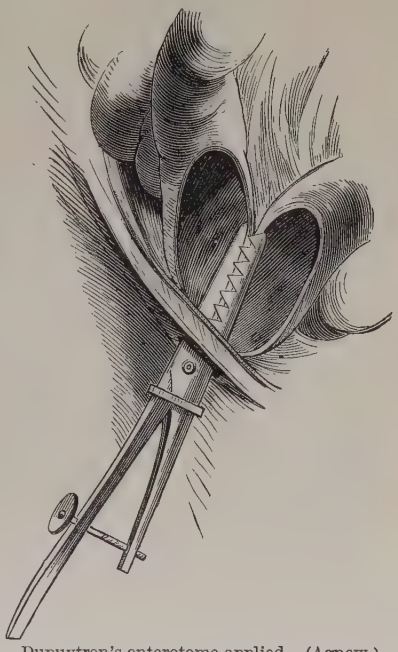
and the spur is not well marked, so that spontaneous cure is the rule. If the opening leads to a part of the intestine very high up there will be marked loss of nutrition, because the food goes to waste, but otherwise the symptoms are limited to the annoyance and the irritation of the surrounding skin by the discharge. When the loop of bowel involved lies deep in the abdomen and the sinus is long and narrow, there is very apt to be retention of the discharge, with a liability to the formation of abscesses or diffuse suppuration about it, a condition which is most frequently seen as a result of appendicitis with abscess. If there is a permanent obstruction to the bowel beyond the seat of the fistula, the latter becomes an artificial anus, and cannot be closed until the distal obstruction is remedied. Fecal fistula is rarely seen as the direct result of tuberculous or cancerous disease of the intestine involving the abdominal wall.

Treatment.—The treatment of fecal fistula should be expectant at first, protecting the skin by ointments and cleanliness, and keeping the external orifice of the sinus open, so that it will close from the bottom, in order to avoid inflammation by retention of the discharge. If the external orifice should close and the patient begin to have fever, even if there is no local sign of abscess, a careful watch should be kept to evacuate the pus at the earliest possible moment. In very serious cases the patient may be kept submerged in a bath maintained at a constant temperature equal to the body heat, the water being changed by a continual fresh supply, thus washing away the discharge and keeping the skin free from irritation.

If the fistula shows no tendency to heal, or frequently relapses, it must be

closed by operation. The first and often the only necessary step is the destruction of the spur. Dupuytren's enterotome (Fig. 782) is an instrument devised for this purpose, consisting of a forceps one branch of which is introduced in each end of the bowel, and the handles are then slowly approximated with a screw, being tightened daily until they cut their way through the adjacent walls, adhesions meanwhile forming around them, so that the peritoneal cavity is not opened in the process. When the two loops of bowel lie close together, this instrument acts admirably; but if the angle between them is open, the tension may prevent the adhesions from forming sufficiently rapidly, and peritonitis may result, or another loop of bowel may lie in the angle and may be caught by the clamp. The spur may also be removed without opening the peritoneal cavity by incising the abdominal wall sufficiently to expose the intestinal ends and dividing the spur by open incision, the mucous membrane at the edges of the latter being sutured across the raw surfaces so as to prevent recontraction. A better method is to open the peritoneal cavity near the fecal fistula and to make an anastomosis between the afferent and efferent loops a short distance from the external opening, thus establishing the circulation of the intestinal contents above the spur. When the spur has been disposed of by section or anastomosis, the external orifice may be closed by any of the ordinary plastic operations for such openings, but it will usually heal spontaneously. A more radical method is resection, the entire external orifice being circumscribed by an incision some distance from its edges, the abdomen opened, and the two adherent ends of bowel drawn out together and cut away, the open ends of the gut being then united as in intestinal resection and the abdominal wound closed as usual. This operation is generally very difficult, on account of the numerous adhesions and the danger of peritoneal infection from the open fecal fistula.

Fig. 782.



Dupuytren's enterotome applied. (Agnew.)

Operations.—Enterotomy.—If it is simply desired to remove a foreign body from the intestine, a laparotomy is done, and the loop of bowel is incised along the border opposite the mesentery. The foreign body is removed, and the wound is closed with Lembert sutures.

Enterostomy.—If it is necessary to make an artificial anus, the opening should be made as low down as possible and just above the obstruction which it is desired to relieve. The small intestine may be opened near the ileocæcal valve, but not above that point, lest the absorption by the bowel above the opening be not sufficient to support life.

Jejunostomy.—In some cases of incurable obstruction of the pylorus or duodenum which cannot be treated by gastro-enterostomy, a loop of the jejunum has been secured in an abdominal wound, so that the patient may be fed in a similar manner to that employed after gastrostomy. The operation is rare and not very successful. It is known as *jejunostomy.*

Colostomy.—Lumbar Operation.—The extraperitoneal or old operation of colostomy (formerly called colotomy) is done in the lumbar region upon the ascending or the descending colon. An incision is made parallel to and one inch below the last rib, extending outward from the edge of the quadratus lumborum. This is deepened until the fat in the neighborhood of the kidney is exposed in the wound. The finger then searches for the bowel, which will usually be found distended in these cases, owing to the obstruction; the peritoneum is pushed aside if it comes in sight, and the bowel is secured by a loop of silk on a curved needle, which is passed through the part not covered with peritoneum, and is drawn into the wound, where it is sutured to the skin and incised.

The intraperitoneal operation is done upon the cæcum, the transverse colon, or, most frequently, the sigmoid flexure. **Iliac Operation.**—The sigmoid flexure may be opened by several methods, the simplest being that of an oblique incision parallel to Poupart's ligament, about half-way between the anterior superior spine of the ilium and the middle line. The peritoneum is incised and sutured to the skin around the edge of the opening, making an aperture in the abdominal wall an inch and a half in length. The loop of the sigmoid is drawn up to the wound and sutured by continuous Lembert stitches to the peritoneal margin. If there is no need of haste, a delay of twenty-four hours before incising the bowel will allow strong adhesions to form. If it is necessary to incise the bowel at once, additional care must be taken to make the stitches very close, so that there shall be no danger of infecting the peritoneum with feces. A better method is to draw the bowel entirely through the abdominal wound and pass a strong glass rod or drainage-tube through its mesentery, so that the glass rod supports the weight of the intestine. A few sutures are made to secure the bowel to the margin of the opening, and also to unite the two limbs of the loop under the rod. The intestine is cut across upon the rod in twenty-four hours, no anæsthetic being required.

Enterectomy, or **Resection.**—To remove a tumor of the bowel, the loop containing it is isolated by two strips of gauze tied around the bowel some distance from the part to be resected, after expressing the contents of the loop. The mesenteric attachment of the portion to be removed is then tied off by several silk or catgut ligatures. The part to be excised is seized with a long clamp on each end, and the bowel divided beyond these clamps. If the tumor is situated near the end of the small intestine or in the large intestine, the two ends of the bowel may be secured in the abdominal wound and an artificial anus made. This is the best procedure if the patient is very feeble, or if the operation is a very tedious one with severe hemorrhage or great shock. Otherwise it is best to unite the ends of the intestine. This may be done by a circular suture, the mucous membrane being united first, then the muscular and serous coats, and finally the serous

coat alone with Lembert's sutures. (See page 921.) Or a lateral anastomosis may be made, both ends of the bowel being closed by a continuous suture, a slit at least three inches long being made on the side opposite the mesenteric border in each end of the bowel, and the edges of these openings united in the same way as in gastro-enterostomy. Finally, the ends may be united by Murphy's button. With a needle threaded with coarse silk a continuous suture is made around each end of the bowel, passing through the entire thickness of its wall close to the cut edge. Half of the button is inserted in each end, and the thread of this suture is drawn tightly around its neck. The two halves are then joined (see page 943), and a continuous Lembert suture is applied outside of all.

Intestinal Anastomosis.—In some cases it is not possible to remove the diseased bowel, and a short cut may then be made around the point of obstruction by forming an anastomosis in which an opening in the bowel above is united to a similar opening in the bowel below, exactly as in the case of gastro-enterostomy, either by sutures or by a Murphy's button. The method by sutures is better, because it allows a much larger opening to be made, and there is a tendency for all such orifices to contract. The incisions in the bowel should be three or four inches long, and should be made opposite to the mesenteric attachment.

Intestinal Exclusion.—An operation has lately come into use which we may term intestinal exclusion. This is useful when a part of the bowel is diseased by a cicatricial stricture or multiple fistulæ or some such condition which is neither malignant nor tuberculous. In such a case the bowel may be divided above and below the point of disease and these two ends united. Both ends of the excluded part may then be closed after irrigating the loop thoroughly, or one end may be left open and secured in the abdominal wound. In this way the circulation of the intestinal contents goes on entirely through the healthy bowel, and the diseased part is relieved from function and from irritation. The general health is restored, and a local cure may be obtained. Although few such operations have as yet been done, excellent results have been claimed, and it is said that the excluded part of the intestine atrophies so completely that it is perfectly safe to close both ends of the isolated loop.

DISEASES OF THE VERMIFORM APPENDIX.

Anatomy.—The normal appendix is about three and a quarter inches long, and is attached to the cæcum just behind its blunt extremity, although another frequent position is exactly at the end of the cæcum, which is then funnel-shaped and continuous with the appendix at its tip. The latter arrangement is found in the fœtus, the former usually in the adult, but the fœtal arrangement occasionally persists. Occasionally the appendix is from seven to nine inches in length, or it may be only half an inch long, or even absent altogether. It is normally an intraperitoneal organ, and very rarely is it found behind the peritoneum. It has a short mesentery which runs behind the cæcum towards the ileo-cæcal valve. The appendix is usually coiled up behind and a little to the inner side of the cæcum, but its position is very variable. It has even been found extending across the body, so that its tip

lay on the left side of the middle line, and abscesses have not infrequently been caused by it in this situation. Whatever its position, its base is always in connection with the anterior longitudinal band of the colon as it runs down over the cæcum, and this can be used as a guide when it is difficult to find.

Pathology.—The vermiform appendix consists of two layers of muscle, longitudinal and circular, covered externally with peritoneum and internally with a mucous membrane resembling that of the cæcum, except that it is very rich in lymphoid tissue. In the diseased state the first change is a catarrhal one, consisting simply of congestion of the mucous membrane, thickening, and an increase of secretion. Foreign bodies are frequently found in the cavity of the appendix, which should normally be empty. These foreign bodies are almost invariably hardened masses of feces, but occasionally in their centre will be found a pin, the seed of a fruit, or some such object. Strictures are frequent, and adhesions often fix the organ in a bent position. In rare cases the distal part of the appendix is entirely shut off by the obliteration of the lumen, and a cyst is formed which may be of large size. Ulcerative inflammation is also common, and may result in perforation. The tip of the appendix or any part of its wall may become gangrenous, or the entire organ may slough.

Appendicitis is much more common in men than in women, and occurs before the thirtieth year in three-quarters of the cases, although it may occur at any age. The causes of appendicitis are not fully understood. In some cases it would seem that ulceration had produced a cicatricial stricture or adhesions, which bent the organ, and the stagnation of its contents thus produced resulted in the production of a fecal concretion, which, in its turn, excited ulceration or sloughing of the wall. In others the sloughing appears to be the result of the intensity of the inflammation. The inflammation is due to bacterial infection, either by the colon bacillus or the ordinary pyogenic germs, and occasionally by the tubercle bacillus. It is probable that constipation and chronic gastro-intestinal disturbance also act as predisposing causes by exciting catarrhal inflammation. Injury by a direct blow has occasionally resulted in perforation of the appendix, and severe muscular effort may injure it by sharp flexion or traction when adhesions exist. Some believe that rheumatism may cause inflammation of the appendix, on account of the large amount of lymphoid tissue, as in the tonsil. The appendix is frequently found in herniæ, on the left side as well as the right, and may become inflamed in this situation.

Varieties of Appendicitis.—There are several clinical varieties of appendicitis: first, **colic of the appendix**, characterized by sharp attacks of pain, accompanied by vomiting, prostration, and tenderness in the region of the appendix, in which early inspection of the parts has shown that there was no inflammatory change in the tissues of the organ. These attacks often occur in patients who have an appendix bound down by adhesions or strictured, being apparently the result of obstructions due to these causes.

The *treatment* of this condition in a first attack should be simply palliative. If the attacks are frequent, however, and do not yield to medical treatment, an operation for removal of the appendix may be necessary.

In the second form, **catarrhal appendicitis**, there may be sharp attacks

of pain in the region of the appendix, with tenderness over it, and even vomiting, but no tumor is to be discovered. The attack passes off under small doses of morphine, the use of a mild purge, and rest in bed, and it is to be distinguished from appendicular colic by the fact that the pain is less acute and the symptoms are of longer duration.

The third variety is **appendicitis with abscess.** In this variety an ulcer develops, or the appendix-wall is slowly penetrated by bacteria, leading to a localized peritonitis, the infection occurring so slowly that adhesions have time to form. In such cases the attack may begin acutely with pain and tenderness and vomiting ; or it may begin very gradually, with a little tenderness in the iliac region, some constipation or diarrhœa, and a general feeling of malaise. The pain increases, vomiting sets in, and the temperature rises, occasionally with a chill. The temperature may be very high, and there may even be a chill in cases without abscess, or there may be no fever when suppuration has occurred. The symptoms may increase until the abscess bursts or is incised, or they may subside, the pus becoming encapsulated. If the abscess is neglected, pyæmia may follow, and the patients who recover are liable to have other attacks.

The fourth variety comprises the cases of **acute perforation of the appendix.** The perforation results from ulceration, or over-distention of an appendix with an impassable stricture. The symptoms are generally very sudden in their onset, the pain being intense, the vomiting persistent, and the tenderness great. A general peritonitis usually follows, although in some cases the acute symptoms may subside and a localized abscess may result. Some cases of perforation also result in peritoneal *septicæmia*, which produces death, with symptoms of profound toxic poisoning, such as vomiting, diarrhœa, and prostration, ending in collapse, without much pain or tenderness, and occasionally without distention or rigidity of the abdomen. The first symptom in the ordinary cases with peritonitis is usually pain, often with great collapse, and the vomiting may set in immediately after or may be delayed. The pain may be general over the abdomen or may be referred at first to the region of the stomach or elsewhere instead of to the iliac region, although it speedily becomes localized in the latter place. In some unusual cases it remains constantly upon the left side of the abdomen or high up in the epigastric region. The tenderness, however, is usually limited from the first to the region of the appendix, and is generally most acute at McBurney's point, which is situated on a line from the anterior superior spinous process of the ilium to the umbilicus, two-thirds of the distance from the former, a point corresponding fairly well with the usual situation of the base of the appendix. A very valuable sign is the rigidity of the right rectus muscle as compared with the left, as it is not found in other conditions, except in peritonitis about the gall-bladder. In some cases, even without a general peritonitis, the entire abdomen is rigid. Sometimes there is vesical tenesmus or retention, or pain shooting down the thigh. The right thigh is held flexed in order to relieve pressure, and there may be retraction of the testicle. Occasionally a tumor can be found at the first examination, and its presence is an encouraging sign, for when there are no limiting adhesions no tumor forms. The tumor can sometimes be

made more evident by forward pressure in the loin by the hand, and occasionally it can be felt in the rectum and not anteriorly, but this is exceptional until late in the disease. The vomiting may be very slight or absent, or it may be very persistent, obstinate vomiting being a sign of general peritonitis or profound sepsis. When the inflammation becomes general, tympanites develops, with an increase of the other symptoms.

The secondary effects of an abscess from appendicitis may be abscess of the liver, subphrenic suppuration, distant metastatic foci, or a general pyæmia, and it is by no means necessary that the abscess around the appendix should be unusually large or infectious to produce this result, as we have seen cases in which the secondary abscesses were the first symptoms noticed by the patient and his family, the disease of the appendix having given no recognizable symptoms.

Chronic appendicitis occurs in several varieties. The symptoms may begin acutely and then quiet down to slight tenderness and attacks of pain, and perhaps constipation, with or without a tumor. If all symptoms disappear and other attacks follow after a completely free interval, the cases are called **recurrent.** If the patient is never entirely well and has numerous exacerbations, the case is known as **relapsing appendicitis.** In both varieties removal of the appendix is advisable in well-marked cases. The lesions found in these cases are various, such as adhesions, thickening of the wall, empyema, encapsulated abscesses, and fecal concretions.

Diagnosis.—Gastro-Enteritis.—The localized pain and tenderness and the great prostration of the patient indicate appendicitis, and the symptoms of gastro-enteritis can generally be brought under control within a short time. The vomiting is apt to be more violent in the gastric attacks. Fecal impaction in the cæcum is said to resemble appendicitis, but it would appear to be a very rare condition according to our modern experience, and the same is true of **typhlitis.** In **gall-stone colic** there will, as a rule, be a history of previous similar attacks of jaundice, or of gall-stones found in the stools, the pain is felt to shoot backward to the right shoulder, and the collapse from the pain is usually greater. In **cholecystitis** the tumor formed by the gall-bladder is rather higher up than the mass felt in appendicitis, and it can usually be felt as a tense round cyst, unless there is a peritoneal abscess around it, while the tumor of the appendicular abscess is more irregular, rather doughy, and less distinct in outline. **Renal colic** may sometimes resemble appendicitis, but the previous history, the reduction in the quantity of urine, and the pain running down the ureter will give the clue, and there will be no tumor in the ileo-cæcal region. A tumor of a kidney which was low down, and particularly a **floating kidney** in which the ureter had become twisted, and some cases of **pyonephrosis,** might give rise to doubt, but a thorough examination of the tumor should settle the diagnosis, the kidney tumor being higher up and more easily reached from the back, and generally being movable upward towards the diaphragm. Obscure cases of **typhoid fever** may sometimes be confounded with appendicitis, especially as pain in the ileo-cæcal region is a common symptom in the early stages, but the pain is less acute, and the presence of an eruption on the abdomen and the characteristic temperature record should prevent confusion.

Prognosis.—The prognosis depends upon the variety of the appendicitis. In the ordinary form it has been estimated that out of seven cases severe enough to be marked by the presence of a tumor, in which operation is limited to opening abscesses, five will resolve under medical treatment, one will form an abscess which will require operation, and one will have a general peritonitis and die. But all the cases of abscess will not be saved by this late operation, so that the mortality would be even greater than one case in seven, and the prognosis under our present methods of early operation is much better than this estimate. Ultimate recovery is not always obtained in those cases which are supposed to have recovered under medical treatment, as fecal fistulæ may result from the bursting of an abscess externally when it already connects with the bowel, or pyæmia may develop from abscesses even after they have discharged themselves into the bowel or externally, and in many cases recurrence takes place.

Treatment.—In selecting the proper treatment it is important to decide, if possible, which variety of the disease is present. The ordinary *colic* requires merely a dose of morphine to relieve the spasm, operation being resorted to only when the case resists ordinary medical treatment and the attacks become frequent. The *resolving* form, whether catarrhal or ulcerative, without a perforation and without the formation of abscesses, is to be treated with cold applications locally, light diet, and rest in bed. As soon as it is certain that no abscess will form, a light purgative may be given. An *abscess* should be suspected when the pain continues in spite of moderate doses of morphine, when vomiting persists or returns after a temporary cessation, or when a distinct tumor can be felt. The temperature is an uncertain guide, but a rapid pulse is a reliable sign of suppuration. The pus is to be discharged as soon as its presence is certain, for there is constant danger that the abscess may burst or that general septic infection may take place. Pus will be found at the end of forty-eight hours in the majority of cases. Delay is certain to result in more extensive adhesions, greater damage to the surrounding parts, and loss of strength to the patient. *General peritonitis* requires immediate laparotomy unless the prostration is so great that operation would certainly cause death. These cases are sometimes difficult to recognize, as they may begin with the symptoms of an ordinary gastro-enteritis, but general peritonitis may be suspected from the rapid loss of strength, the sudden development of shock, the beginning tympanites, or the violent vomiting. No tumor is found, as a rule, and pain is not a reliable symptom in these cases, being in some instances very severe, in others very slight. As a rule, the presence of severe pain indicates a better prognosis, for pain is frequently absent in cases of peritoneal septicæmia.

Operations.—In the great majority of cases of appendicitis an abscess will be found at the time of operation, and the treatment of the latter is to be conducted on the principles previously laid down for localized peritonitis, page 927. If general peritonitis is present, a laparotomy should be done as described on page 928. The best incision for reaching abscesses in appendicitis is a vertical one at the outer border of the right rectus muscle, extending downward from the level of the umbilicus. But it should always be

made over the most prominent part of the tumor, and if the latter is low down the safest incision is an oblique one near Poupart's ligament and parallel with the latter. When the abscess is very large or dips far down in the loin, a counter-opening here may be of advantage for drainage, the anterior incision being sutured nearly completely. In operating for these abscesses the wound should be carefully deepened until the peritoneum is opened, and then if adhesions are found they should be cautiously separated until pus is reached. If possible, the appendix should be removed, as it is liable to occasion recurrence of the trouble or a persistent sinus in the wound. But if the patient's condition is so bad that it is dangerous to prolong the operation by a search for the appendix, or if the removal of the latter necessitates breaking down adhesions and opening the general peritoneal cavity when it is well shut off, it is safer to leave it and simply to pack the wound. The methods of resection of the appendix are described below.

When the appendix is to be removed for chronic or relapsing appendicitis or for appendicular colic, an incision is made through the right rectus muscle, near to and parallel with its border, or, by the McBurney method, through the fibres of the external and internal oblique, without dividing them. (See page 919.) Before separating the adhesions, gauze or sponges should be packed around the inflammatory mass so as to protect the free peritoneal cavity. Adherent omentum is ligated and divided and the appendix isolated. It may be very difficult, or even impossible, to find the appendix, and in some cases it is absent, having been destroyed by the former acute inflammation or atrophied by a chronic process.

A ligature is passed through the mesentery of the appendix and tied, and that membrane divided. Within half an inch of the cæcum the peritoneal coat is divided circularly around the appendix, and stripped backward with or without the muscular coat, making a circular cuff-flap. A silk ligature is then tied around the mucous lining of the tube at the base of this flap, and, a clamp having been placed on the appendix distally to prevent the escape of its contents, the mucous membrane is divided between the clamp and the ligature. The reflected cuff of peritoneum is then turned down, its edges inverted, and a couple of Lembert sutures passed through it. Some surgeons prefer not to ligate the mucous membrane, but simply to cut the appendix across, closing the distal end with a clamp or ligature, and compressing the proximal end with the fingers, and then to invaginate the stump into the cæcum and secure the whole with a purse-string Lembert suture. The latter method is difficult when the tissues are thickened, and there is a liability to the escape of fecal contents. In some cases neither procedure may be possible, on account of the adhesions and alteration of the walls of the appendix and the cæcum, or great haste may be necessary because the patient is in collapse, and the appendix is then to be ligated at its base and cut away, the mucous membrane of the stump being destroyed by the thermo-cautery or pure carbolic acid, and the little cavity filled with iodoform powder. Even by this incomplete method primary union of the wound may be obtained. When the appendix has been removed, any granulating surface should be curetted, and the wound may be closed without

drainage if it is possible to remove all the infected tissue; otherwise a small drain should be inserted.

Nothing should be given to move the bowels for some days, for fear of rupturing the sutures at the stump of the appendix, for we have more than once seen this accident so caused. A fecal fistula may form in the wound as the result of perforation of the intestinal wall by the suppurative process, making the cavity of the bowel communicate with the abscess. Should this occur, the wound must be widely opened, thoroughly cleaned, and packed to its full extent. Healing by granulation will usually take place, and finally the fistula will be obliterated. If it should not, an operation will be necessary, but it should be postponed for several months. Hernia is very common after operations for appendicitis, especially in cases with abscess in which the wound has been packed, for the wide scar is a weak one and easily stretches. After every operation for appendicitis the patient should wear an abdominal belt, fitted with a hard rubber plate secured directly over the scar, for at least a year. If the abdominal wall shows signs of weakness, the belt should be continued, or the old scar may be excised and the wound sutured as in the operation for ventral hernia.

INTESTINAL OBSTRUCTION.

In the condition known as intestinal obstruction there may be simply a mechanical occlusion of the lumen of the bowel, or the occlusion may be accompanied by strangulation of the gut, and in some cases there may be strangulation without occlusion, as when the cæcum or the appendix is strangulated. Intestinal obstruction may be compared to ordinary hernia, which may be obstructed or strangulated, or both.

Varieties.—Clinically, we divide the cases of intestinal obstruction into acute, subacute, and chronic, and in the subacute and chronic varieties we recognize a complete and an incomplete obstruction, for in some cases a small amount of material is able to pass by the seat of obstruction. Intestinal obstruction is the result of various conditions, such as—

(1) **Paralysis.** Paralysis of the bowel may be caused by peritonitis, by the compression in a strangulated hernia, or by a severe blow. It may be general or limited to a small loop of the bowel, and in the latter case the obstruction may not be complete, for the contents of the intestine may be pushed through the paralyzed loop by the active bowel above. Some cases of inflammation of the bowel-wall appear to be accompanied by paralysis and serious interference with the fecal movement.

(2) **Fecal impaction.** If the contents of the bowel are allowed to accumulate, a hard mass is formed which is very difficult to break up. These collections are most frequently found in the rectum, but also in the sigmoid flexure and the cæcum. In extreme instances the entire large intestine may be distended with feces, and in such cases the patient has been known to go without a movement of the bowels for two or three weeks.

(3) **Foreign bodies and gall-stones.** A foreign body may be swallowed, or a large gall-stone may perforate the gall-bladder or ducts, and enter the intestine. Gall-stones are said to perforate the large intestine most frequently, but they also enter the small intestine, particularly the duodenum.

Over one hundred operations in cases of obstruction due to gall-stones are on record. A gall-stone may become impacted in any part of the small intestine, but most frequently at its narrowest portion, the ileo-cæcal valve. Gall-stones sometimes accumulate layers of fecal matter as they lie in the bowel, and thus constitute the larger number of enteroliths, although the latter have been known to form about various foreign substances. Enteroliths may attain such a large size as to distend the bowel. Obstruction has also been caused in children by masses of round worms. Foreign bodies may perforate the intestine and cause a general peritonitis or an abscess, and recovery has followed the removal of foreign bodies, such as a fork or spoon, from such abscesses.

(4) **Stricture,** by which we understand a reduction of the lumen of the bowel by various causes. There may be a congenital narrowing at some part of the bowel where the junction of the different loops takes place in fœtal life. The stricture may be cicatricial, owing to the healing of some ulcer or inflammatory process. The narrowing may be due also to tumors pressing upon the bowel or growing into its lumen. Under this head we include hæmatoceles formed in the wall of the bowel beneath the mucous membrane, any inflammatory thickening of the bowel-wall, and external hæmatoceles or abscesses.

(5) **Bands.** Obstruction may be caused by bands of organized lymph formed in peritonitis, which pass across the abdomen from one organ to another or to the abdominal wall. A loop of bowel may be caught under such a band or surrounded by it, and either simple occlusion or strangulation may result. (Fig. 783.)

Fig. 783.

Constriction of a loop of gut by a band. (Agnew.)

(6) **Adhesions.** Adhesions may form between the bowel and the abdominal wall or some of the viscera, which may directly compress the bowel or hold it in a bent position, or simply bind it down so as to impede the peristaltic movements. We have seen a flexion produced by an adhesion to inflamed tuberculous mesenteric glands.

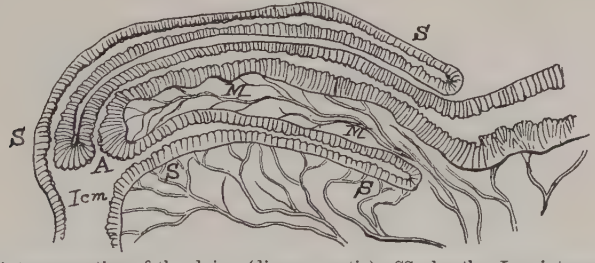
(7) **Diverticula.** Intestinal diverticula are not infrequent—especially Meckel's diverticulum in the ileum, being the result of incomplete fœtal changes, and they may interfere with the movements of the bowel as do the peritoneal bands by forming adhesions and dragging on the bowel or binding it down, or even surrounding it like a cord. The appendix vermiformis may act in a similar fashion.

(8) **Apertures.** There may be internal hernia or strangulation through a natural aperture in the peritoneum, such as the foramen of Winslow, or through artificial openings made by atrophy of the mesentery, for the latter occasionally produces openings an inch or more in diameter. Strangulation may also take place through abnormal openings formed by adhesions or bands.

(9) **Volvulus.** Volvulus is a twisting of any part of the bowel which has a long mesentery, either the small intestine or the sigmoid flexure, a loop being given a quarter or half turn, or even a complete rotation on its axis. The twisted loop is free at its centre, but its ends are closed by the rotation, and its blood-supply may be shut off by the twist in the mesentery so that gangrene results. Volvulus occurs four times as often in males as in females, and appears to be more common in certain races, notably the Russians, in whom the sigmoid flexure appears to have an unusually long mesocolon.

(10) **Intussusception.** In intussusception a portion of the bowel becomes invaginated, or "telescoped," into that immediately below it, like the inverted finger of a glove. Intussusception occurs in both the large and the small intestine, but is most frequent at the ileo-cæcal valve. In some cases a polypus hanging in the bowel may drag the wall of the latter inward during peristaltic action, but in the majority of cases intussusception is due to an irregular peristaltic movement. Invagination of the bowel can be produced in animals by applying an electrode to the bowel, the part where the current is strongest becoming firmly contracted, and the neighboring part can be seen to creep up over it, as it were, by peristaltic action, making it seem as if the active part of the process was taken by the outer layer rather than by the inner. In such an invaginated loop there are three layers, the innermost layer being contracted intestine, the middle layer being turned inside out over the former, and the two together forming the invaginated part, or intussusceptum. (Fig. 784.) The intussusceptum is

Fig. 784.



Frozen section of intussusception of the dying (diagrammatic): *SS*, sheath; *Icm*, intussusceptum; *A*, apex of latter; *MM*, mesentery of latter.

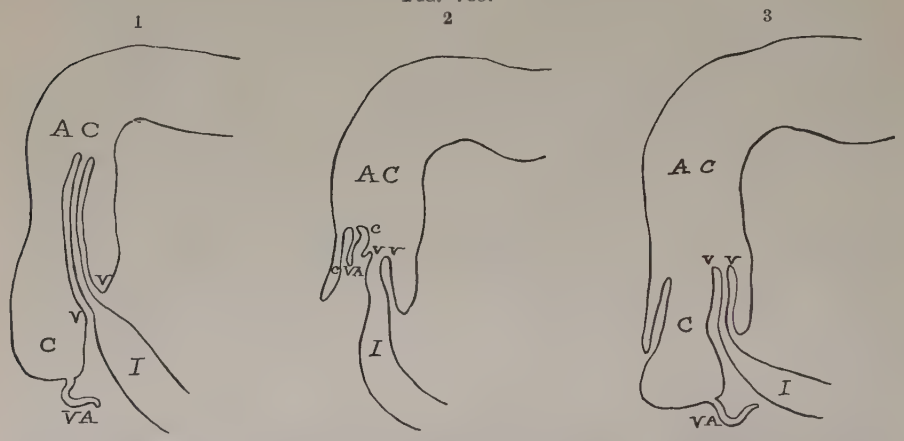
contained in a third layer, which retains its natural position but is distended by the invaginated gut and its mesentery. This outermost layer is called the intussuscipiens, or sheath.

Intussusception is frequently found after death in children who have died of nervous or intestinal diseases. This form is called *intussusception of the dying*, and the invagination is frequently directed upward against the normal peristaltic movement, whereas in life we find the apex of the intussusception almost invariably directed towards the anus. The intussusception may be only an inch or so in length, or it may involve the entire large intestine and most of the small, the ileo-cæcal valve, for instance, having been seen to protrude from the anus.

In the ileo-cæcal region there are two varieties of intussusception—the ileo-cæcal and the ileo-colic. (Fig. 785.) If the valve remains intact and

is pushed forward into the colon at the head of the intussusception, we have the *ileo-cæcal* form. The cæcum may be inverted with the valve, or the inversion may begin with the junction of the colon and the cæcum, the cæcum and the ileum then advancing together without inversion, and forming the intussusceptum as they lie side by side. This last variety is very rare. In the *ileo-colic* form the valve remains in place, but opens, and the lower part of the ileum is inverted through it into the colon. The ileo-

FIG. 785.



Varieties of intussusception.—1, ileo-colic; 2, ileo-cæcal, ordinary form; 3, ileo-cæcal, rare form. *I*, ileum; *AC*, ascending colon; *vv*, ileo-cæcal valve; *C*, cæcum (inverted in Fig. 2); *VA*, vermiform appendix.

cæcal form is the most common of all. Next in frequency comes intussusception of the small intestine, then that of the large intestine, and finally the ileo-colic. Over one-half of the cases of intussusception occur in children under eleven years of age, and three-quarters of these cases are of the ileo-cæcal variety. In rare instances there are more than three layers of the bowel, a second intussusception forming outside of the first, so that there may be as many as six layers instead of three.

The first change that occurs in a case of intussusception is interference with the circulation of the intussusceptum, its blood-vessels being strangulated at the neck of the tumor. Œdema and swelling take place, which still further obstruct the lumen of the bowel. Adhesions form between the opposed serous surfaces, and ulceration occurs on the mucous surface. Reduction of the intussusception can take place only in the earliest stages, because even twelve hours after the beginning of the attack the adhesions and swelling may prevent it. If the strangulation is long continued, the intussusceptum will die and slough away. If the slough does not separate until the adhesions around the neck are strong, no peritonitis is set up, and the slough passes off by the bowel, the lumen of the canal being thus restored. This happy termination, however, is rare, for the serous adhesions are seldom so complete as to prevent peritonitis when the slough separates, or the swollen intussusceptum may cause perforation of the wall of the sheath and result in peritonitis. Even when the slough has separated the cure is not complete, for a cicatricial stricture may form at the neck of the invagination

and cause chronic obstruction. In some cases the strangulation is not severe enough to cause sloughing, but the adhesions prevent reduction, and the fecal movement is restored by a canal which opens through the centre of the intussusception by partial sloughing or ulceration, and the condition of *chronic intussusception* is produced, which may last for months or years, but is usually fatal in the end.

Symptoms.—The symptoms of intestinal obstruction are, in the first place, vomiting, which may be very violent or may amount only to regurgitation, the latter being the rule in cases of chronic obstruction. It will be the first symptom when strangulation is present, and will begin late when there is a simple mechanical obstruction to the lumen of the bowel, especially if the obstruction is low down. It is not usually accompanied by nausea. Pain is an unimportant sign, although colicky pain is generally present in acute strangulation. The pain may be situated anywhere in the abdomen, but occasionally there is localized tenderness at the point of obstruction. Tympanites, by which we understand distention of the abdomen with tympanitic resonance, is the most constant of the local signs. The distention is due to paralysis of the bowel and the decomposition of the fluids contained in it. It has been shown that this paralysis first becomes evident and is most marked in the strangulated loop, so that by an early examination the exact situation of the obstruction can be determined, especially in volvulus or in strangulation by bands. Rectal movements and even the passage of gas are suspended, but in intussusception there is a discharge of mucus and blood from the rectum, with tenesmus.

The temperature in intestinal obstruction is low, and may be subnormal. Auscultation gives little clue to the seat of the obstruction, but in some cases the peristaltic wave can be heard moving towards the obstruction, becoming louder as it approaches that point and then ceasing. The peristaltic movements may be seen through the abdominal wall, especially in cases of chronic obstruction with great hypertrophy and distention of the bowel. They can occasionally be stimulated by laying a cold hand upon the skin or slapping it with a wet towel. A tumor is present in some cases, generally being formed by a strangulated loop, a volvulus, or an intussusception.

In acute intestinal obstruction with strangulation the patient is suddenly taken with pain in the abdomen and vomiting, and falls into a condition of collapse. The onset is abrupt, the pain severe, the constipation absolute. The vomiting becomes more and more violent, the contents of the stomach first being voided, then bile, and finally fecal matter from anti-peristalsis in the upper intestine. The pulse is imperceptible, there is cold perspiration, and the patient is very restless. The pain may be slight or very severe, and it is generally localized at the seat of the obstruction. There is no movement from the bowels, not even gas being passed. There may be retention of urine, but more frequently the secretion is suppressed. In the subacute form the symptoms come on more slowly, but in a few hours reach the same intensity. In the chronic form, on the other hand, the passages may gradually diminish in size and frequency, or constipation may exist for some weeks or months beforehand, so that the bowel becomes accustomed to the obstruc-

tion. The movements may be of very small diameter. Constipation and diarrhœa are apt to alternate. The general condition of the patient in these cases does not suffer at first, and complete obstruction, without even the passage of gas, has been known to exist for ten days or a fortnight and yet recovery take place.

Diagnosis.—It is, in the first place, essential to determine whether strangulation is present, the symptoms of this condition being the acute pain and the uncontrollable vomiting, which rapidly becomes fecal. If there are symptoms of strangulation, all the hernial apertures must be examined, in order to exclude the presence of strangulated hernia. Acute peritonitis caused by perforation sometimes resembles intestinal obstruction, but may be recognized by the more intense generalized and steady pain, the great abdominal tenderness, and the rise of temperature following the acute collapse. Appendicitis with perforation is often the cause of intestinal obstruction, either from the inflammatory paralysis of the bowel or from the mechanical effect of adhesions about the appendix, but the local symptoms should overshadow those of obstruction. Thrombosis of the mesenteric veins and acute inflammation of the pancreas may also resemble obstruction.

The diagnosis of the various kinds of obstruction must be made from the clinical history together with the local examination. Thus, **acute obstruction** is most frequently the result of intussusception, then of strangulation by bands or through apertures, of volvulus, or impacted foreign bodies, and rarely of stricture or paralysis. It should be noted, however, that acute obstruction may suddenly develop upon a chronic condition, and a malignant stricture of the large intestine has been known to occasion no symptoms whatever until it had become so small as to be blocked by an appleseed, causing acute obstruction with a fatal result. **Subacute obstruction** is most frequently seen as the result of foreign bodies, of stricture, of adhesions, and of strangulation by bands or through apertures. **Chronic obstruction** is most commonly found in paralysis of the intestine, fecal impaction, stricture, or adhesions. Chronic intussusception is uncommon. Rarely we find chronic obstruction due to foreign bodies or incarceration by bands or through apertures.

Strangulation by **bands, apertures,** and **diverticula** is most commonly found in adults, and with a history of preceding peritonitis, abdominal injury, or hernia. The vomiting begins early, and soon becomes fecal, the constipation is absolute, but tympanites does not become well marked for three or four days, there is no tenderness nor rectal tenesmus, and there may be no tumor. The prostration, however, may be extreme.

In **volvulus** of the sigmoid flexure the patient is generally a male past middle age, with a history of constipation. The vomiting is not marked, and is seldom fecal. Tympanites begins at first in the occluded loop, and may be limited to that throughout, as has been shown by Von Wahl, but it must be remembered that a distended sigmoid flexure may be so large in these cases as to fill the entire abdomen, so that no limited tumor can be distinguished. As a rule, however, a tumor is felt between the navel and the iliac spine or Poupart's ligament. There may be tenderness in the left iliac region and some rectal tenesmus.

Acute intussusception occurs in children under ten years of age in one-half of the cases, and the majority of these cases occur in children under three. There is often a history of colic or of purgatives having been given. Vomiting is usually present, becoming fecal early. Constipation has been present, or diarrhœa, but they have given place to small frequent passages of mucus and blood with tenesmus. Tympanites is rare at first. The intussusception can be felt in the abdomen as a sausage-like mass, which is more or less fixed when situated in the large intestine, but is movable when in the small. The tumor will generally be felt in the iliac regions or on the right side higher up. Its apex can frequently be reached by the finger in the rectum, and occasionally it protrudes from the anus.

In cases of obstruction by a true **foreign body**, the history will give a clue to the cause. In **gall-stone impaction** there will be an account of frequent attacks of gall-stone colic (although in rare cases this may be absent), and of an attack of local peritonitis, marking the time at which the gall-stones entered the intestine. In some instances the gall-stone will be large enough to be felt through the abdominal wall. The symptoms are of the subacute type, and fecal vomiting occurs late. Gas is frequently passed per anum, and sometimes the symptoms are intermittent.

Chronic Obstruction.—Fecal impaction is the most common cause of chronic obstruction in women, especially when hysteria or insanity is present. Constipation and stomach disturbance have often preceded the attack, and the symptoms develop gradually, although they may finally become as intense as in the acute varieties. The distended bowel may be felt distinctly, being doughy, dull on percussion, and not tender, and the mass takes the impression of the fingers when pressed firmly upon it.

Adhesions and **stricture** present chronic symptoms, which develop slowly, but progress steadily to complete obstruction, with fecal vomiting. In these cases the abdominal distention is apt to be extreme and fecal vomiting is a late symptom.

Cicatricial stricture is usually preceded by some intestinal inflammation, such as syphilitic ulcers or dysentery. In stricture due to a **malignant tumor** there is slowly increasing constipation, occurring in a patient over middle age, with gradually increasing attacks of obstruction lasting a few days at a time, with vomiting and pain. There may be alternating diarrhœa and constipation. There is gradual loss of flesh and strength, and the skin acquires a dull yellowish color. A tumor may be detected in the malignant cases, and it is generally small and rather uneven on its surface, and occasionally tender. Blood and pus may be found in the movements. The stricture is often so low down as to be reached by the finger in the rectum.

Chronic intussusception usually has an acute beginning, and a tumor of considerable size is generally felt in the rectum, in the neighborhood of the transverse colon, or occasionally in the sigmoid flexure.

Prognosis.—The outcome of intestinal obstruction depends chiefly upon the existence of strangulation. When there is no strangulation the result varies in the different conditions causing the obstruction, as already described, but the prognosis is in most cases better than when strangulation is present, spontaneous recovery being almost unknown in the latter condition.

If the intestinal strangulation is not relieved, peritonitis is caused by perforation of the affected bowel, or the penetration of its wall by bacteria, its blood-supply being impaired or entirely shut off. The peritonitis may be general, or localized by adhesions. If adhesions form about the involved intestine, ulceration or sloughing may result in the formation of an abscess and an external fecal fistula, or in a natural anastomosis between the bowel above and below the point of obstruction, recovery by these means being possible, but very rare. Death may be caused by peritonitis; by exhaustion from the pain, vomiting, and inanition; by toxic poisoning from the decomposing intestinal contents; or by pneumonia set up by inhalation of the vomited material. It may occur in two days or in several weeks.

Treatment.—In the acute form of intestinal obstruction the cause must be removed by mechanical means or a laparotomy must be done at once. Medical treatment is useless. In the subacute form medical treatment may be given a short trial, but if not immediately successful surgical measures must be adopted, as the only chance lies in the early performance of an operation, and even a short delay may be fatal. In the chronic form, medical measures often suffice to keep the patient tolerably comfortable, but an operation is sometimes desirable.

Medical treatment should consist in the use of **enemata**; strong purgatives given by the mouth should be especially avoided, except in chronic obstruction, as they only excite unusual peristalsis, which increases the vomiting and the distress of the patient. For an enema, spirit of turpentine, sulphate of magnesium in large doses, infusion of the leaves of senna, and castor oil may be employed, given through a tube passed as high up in the bowel as possible and with as large a quantity of water as the patient will bear. It should be given under a pressure of from three to five feet.

Vomiting is frequently relieved by **washing the stomach**, and this may sometimes be followed by throwing small quantities of peptonized milk or stimulants into the stomach through the tube. No solid food should be given, and only small quantities of fluids by the mouth, as the power of absorption is very limited, and attempts at feeding only increase the vomiting.

In intussusception an attempt at reduction by **rectal injections** of air or fluid is first to be made. Water is to be preferred for injection, because it is more easily controlled, and the pressure must not be great, because the softened wall of the bowel may give way. Experience has shown that the pressure of a column of water three feet in height is sufficient to reduce the majority of reducible intussusceptions, and five feet certainly should not be exceeded, as that pressure has been known to produce rupture of the intestine in experiments. The injection is given by inserting the tube, around which a bandage has been wrapped so as to make a plug for the anus, and connecting it with the bag of a fountain syringe held a measured distance above the patient as he lies on his abdomen with the buttocks raised on a cushion. If this attempt is not successful under an anæsthetic after a thorough trial of half an hour, **laparotomy for reduction** of the intussusception by the fingers becomes necessary. Great care must be taken not to rupture the bowel-wall in attempting the reduction. The only hope of success in these operations is their early performance—in less than twenty-four

hours after the beginning of the symptoms. If the adhesions are so strong as to prevent reduction, the intussusception may be cut away and the ends of the bowel secured in the abdominal wound, but up to the present time no recoveries have followed this treatment in children, and but few in adults.

The surgical treatment of intestinal obstruction consists in laparotomy or enterostomy. The laparotomy must be done, as a rule, in an exploratory manner, as the diagnosis will be uncertain both as to the cause and as to the situation of the obstruction. The abdomen is to be opened by a median incision large enough to introduce the hand, in order to search for the cause of the obstruction. If a tumor is distinctly felt and is fixed at one side of the belly, a lateral incision over it may be more convenient. If the lesion cannot be found at once, the cæcum should be examined, for its distention proves that the obstruction is below it, and the sigmoid flexure should then be examined. If the cæcum is not distended, the obstruction must be in the small intestine, and the first loop of collapsed bowel which can be found is to be drawn up into the wound and the intestine passed rapidly through the fingers until it leads to the seat of the obstruction. Any bands or adhesions which are found are to be separated. Hernia through any of the internal apertures is corrected by reduction, and intussusception is to be treated as already indicated. A volvulus is to be carefully untwisted and stitches taken in the mesentery so as to shorten it and prevent a recurrence. In all these manipulations great care is necessary to avoid doing damage to the strangulated bowel, especially if the symptoms have lasted more than twenty-four hours, when the gut becomes very soft and is easily torn.

If a foreign body is found in the intestine, an incision is made opposite to the mesenteric attachment, and after the removal of the foreign body the incision may be sutured, or the opening in the bowel may be secured in the abdominal wound by sutures, or it may be temporarily closed by clamps and left in the wound in case collapse makes it necessary.

The great danger in all these operations lies in the fact that the patient is usually very feeble or in collapse by the time that consent to operation is obtained. The collapse may be counteracted by hot bottles about the patient, by elevating the foot of the bed, and by vigorous stimulation.

The stomach should always be washed out before the operation is begun, as this will lessen the danger of aspiration of vomited fecal material into the lungs during unconsciousness from the anæsthetic, and of a subsequent septic pneumonia.

If the cause of obstruction is such that it cannot be removed or corrected, we may leave it untouched and open the bowel above it, or make an anastomosis by connecting the bowel above and below the seat of the obstruction ; or we may resect the bowel at the affected point, and either unite the ends or secure them in the abdominal wound. It will generally be unwise to attempt prolonged operations on these patients, on account of their exhausted condition, so that anastomosis and union of the ends are impracticable, and it is therefore frequently necessary to adopt the expedient of making an artificial anus by securing the ends of the bowel in the abdominal wound after resection. The simplest method is always the best,

and if there is no strangulation the point of obstruction should be left untouched and an artificial anus made above. When the patient has recovered his strength, the surgeon can perform an anastomosis or resection of the affected part of the bowel at a subsequent operation. Sometimes the obstruction disappears spontaneously, and if this is the case, or if it is removed by a subsequent operation, the artificial anus will usually close of its own accord. Many cases are brought to the surgeon so late that the patient is exhausted and an extensive laparotomy is out of the question, the performance of a **colostomy** being the only resource. The opening should be made in the sigmoid flexure, if it is certain that the obstruction is below that point. Otherwise the abdomen should be incised in the right iliac region, and the cæcum opened if it is found distended. If the cæcum is collapsed or not found, the most convenient distended loop of bowel is to be secured and opened. The patient's condition may be such that it is dangerous to administer a general anæsthetic, but with the aid of cocaine an artificial anus may be made, and a limited exploration of the abdominal cavity may be carried out without causing great suffering.

SURGICAL DISEASES OF THE PANCREAS.

Hemorrhage.—Hemorrhages take place in the substance of the pancreas from unknown causes, and may produce fatal results. The blood may collect behind the peritoneum, or in the gland itself, and its quantity is usually not very great. The symptoms are acute pain in the abdomen, vomiting, and constipation, and they closely resemble those of acute perforative peritonitis and intestinal obstruction.

Inflammation.—Suppurative inflammation of the pancreas may result in the formation of small multiple abscesses or a single large collection of pus. The symptoms are local pain extending to the back, vomiting, and constipation, followed by diarrhœa. Fever appears on the second or third day, with some tympanites limited to the epigastrium, and a progressive emaciation. If death is postponed the characteristic diarrhœa and vomiting appear, with fatty globules in the stools and vomited matter. There may be sugar in the urine. For multiple abscesses surgery can do nothing, but a single abscess might be evacuated, and, if limited to the glandular substance, it might be treated by extirpation of that part of the organ.

Gangrene of the pancreas presents symptoms resembling those of inflammation, and is followed by pyæmia or peritonitis. In rare cases recovery has taken place, the sloughs making their way into the bowel. One case which was operated upon through an error in diagnosis resulted fatally. These various conditions of the pancreas cause symptoms resembling those of peritonitis or intestinal obstruction, and if a laparotomy should be performed, and nothing else be found when the abdomen is opened, the surgeon should always examine the region of the pancreas.

Tumors.—Tumors of the pancreas may be cystic or solid.

Cysts.—The cysts are supposed to be retention cysts from obstruction in the duct caused by a calculus, a stricture (often of traumatic origin), or a neoplasm. The cysts most frequently originate in the tail of the organ. They grow behind the peritoneum, and may project forward between the

stomach and the colon, or below both of those organs, or between the liver and the stomach. Adhesions of the cyst to the organs about it or to the great vessels are very frequently, although not invariably, present.

A pancreatic cyst forms a slowly growing tumor in the abdomen, fixed in the middle line, not moving with respiration. An area of resonance will separate it from the liver, as a rule, although if the tumor should come forward between the liver and the stomach the area of dulness on percussion over it would be continuous with the hepatic dulness. The cyst usually attains the size of a man's head, but may be much larger. The general symptoms are those excited by the pressure of the tumor, discomfort, vomiting, and constipation, together with disturbance of digestion from loss of pancreatic fluid. There may be sugar in the urine.

Solid Tumors.—Cancer of the pancreas is not common, and benign solid tumors are rare. The symptoms of solid tumors are due to the obstruction they cause to the common bile-duct and pancreatic duct, preventing the flow of bile and pancreatic juice and interfering with the digestion, free fat appearing in the stools. There may be symptoms of biliary obstruction, such as jaundice and more or less pain in the epigastrium, and cachexia. The tumors are of small size and slow growth, and the diagnosis can seldom be made in time to permit of operative treatment. Similar symptoms are caused by carcinoma of the duodenal mucous membrane beginning at the papilla, as in a case observed by us.

Treatment.—These tumors require operation, but the solid tumors are seldom recognized in time for such treatment. To remove a pancreatic cyst the abdomen is opened by a median incision. The wall of the cyst will be found to be covered by the omentum or mesocolon, or possibly the gastrohepatic ligament. The posterior layer of the peritoneum must be divided, and then the cyst-wall can be exposed. An aspirating needle or trocar is thrust into the cyst and the contents evacuated. The opening is then closed with a clamp, and the adhesions of the cyst carefully examined, and if these are not too strong they may be separated. The pedicle, which is usually formed by the tail of the pancreas, is ligated, or that part of the pancreas from which it springs is ligated as a pedicle. The tumor can then be cut away. If the adhesions are too strong for safe separation the sac is to be drawn out and sutured in the abdominal wound, after which the greater part of it can usually be removed, and the remaining cavity of the cyst is to be drained. In some cases the anterior portion of the cyst-wall can be cut away, and its edges closely united by sutures after a drain has been passed through a lumbar wound into the bottom of the cyst. The abdominal wound can then be closed completely. The mortality of this operation is from fourteen to twenty per cent. The old operation of securing the cyst in the abdominal wall and waiting for adhesions to form before opening it for drainage is not so satisfactory.

SURGICAL DISEASES OF THE SPLEEN.

Wandering Spleen.—The peritoneal attachments of the spleen may be so elongated as to allow it to move about in the abdomen, and even to descend into the pelvis. This condition is called wandering spleen, and

gives rise to vague feelings of abdominal distress, or the tumor may be discovered accidentally. The pedicle may become twisted, and then the organ becomes swollen and painful, and gangrene may follow. A wandering spleen may be fixed by a large pad and bandage, but this is seldom very effective. Recently attempts have been made to secure the organ in place by the operation of **splenopexy.** This may be done by opening the abdomen, dissecting up a flap from the parietal peritoneum in the left hypochondrium, and securing it across the spleen to form a pocket to hold the organ. The operation appears to be without danger and to give good results. The displaced spleen has frequently been removed with success.

Suppurative inflammation of the spleen resulting in abscess is usually of metastatic origin. There may be a single abscess or multiple small foci. The abscesses may open spontaneously into the bowel or externally, but the drainage is incomplete, and unless an operation is done the patient usually dies of pyæmia.

Tumors.—The spleen may be enlarged by congestion in any condition which obstructs the portal circulation. It is liable to hypertrophy in malarial fever, in leukæmia, and also from unknown cases. In chronic enlargement the organ usually becomes fibrous. Neoplasms and cysts of the spleen are rare, even sarcoma being uncommon. They give rise to few symptoms except those caused by their mechanical effects when of large size.

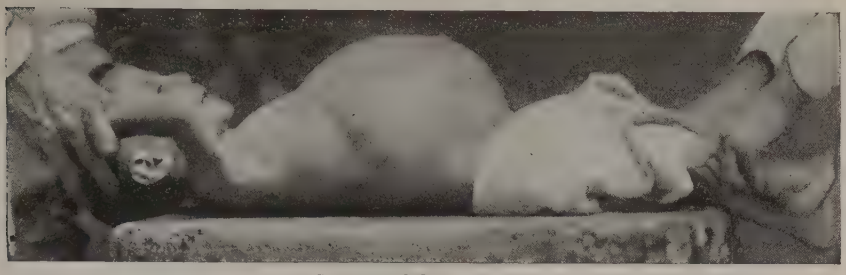
Splenectomy.—The spleen may be removed without danger of disturbing the health, its functions being apparently perfectly supplied by the other lymphatic glands. The most favorable results in splenectomy are obtained in cases of injury, especially when the spleen is prolapsed through an abdominal wound. In operations for hypertrophy of the spleen and for sarcoma about one-third of the cases die. Secondary enlargement from disease of the liver should not be operated upon. Nor should the leukæmic spleen be removed, as it has been found that the mortality in these cases is very high, and the disease of the blood is incurable. Malarial hypertrophy of the spleen usually subsides under medical treatment, but splenectomy may be necessary when the tumors are large and of long standing. The spleen when broken down and sloughing in an abscess-sac has also been removed successfully. When the organ is large, adhesions may form between it and the diaphragm and add greatly to the difficulty of removal. Splenectomy is done by an anterior laparotomy, usually requiring a very large incision on account of the huge size of the organ. The spleen is drawn out of the wound, and a ligature is passed through the pedicle, a very blunt ligature-passer being used on account of the friable nature of the thin-walled splenic vein. The tumor is then cut away, leaving a large stump of the pedicle to prevent the ligature from slipping, and the wound is closed. The chief dangers of the operation are hemorrhage and shock, and secondary or intermediate hemorrhage from the pedicle is not uncommon.

THE DIAGNOSIS OF ABDOMINAL TUMORS.

Physical Signs.—**Inspection** will often reveal at once the presence of tumor. When there is ascites and the patient lies on the back, the belly

bulges equally in the flanks on both sides and is flattened anteriorly. The presence of a large abdominal cyst gives quite a different shape to the body,

Fig. 786.



Sarcoma of the mesentery.

the most prominent part of the abdomen being in the middle line, while the flanks are comparatively flat (Fig. 786), and sometimes one side is more distended than the other. In ovarian cysts the swelling is most prominent in the lower part of the abdomen, and the solid fibroid tumors of the uterus project in the same region, but often make a more distinct and conical protrusion. (Fig. 787.) Large fibro-cystic tumors (Fig. 788) may resemble ovarian cysts. In examining the abdomen by **palpation** the patient should lie upon the back, with the shoulders supported on a pillow and the knees drawn up and held by an assistant, so as to relax the abdominal muscles thoroughly. He should then be instructed to take several long breaths, the surgeon gently sinking the hand into the abdomen during expiration. The palmar surfaces of the fingers should be used as far as possible, and not their ends. When this examination has been completed, the surgeon should turn the patient upon each side and percuss and palpate the abdomen in these positions, as additional information may sometimes thus be obtained. The patient may also be seated upon a chair, bending forward, with his folded arms supported upon the back of a chair in front of him, and his head resting upon his arms, as in this position the abdominal muscles are relaxed, and gravity throws the organs forward against the palpating hand as the surgeon stands behind the patient and reaches around him. The administration of an anæsthetic is useful in palpation of the abdomen, and sometimes indispensable, for some patients cannot relax their muscles.

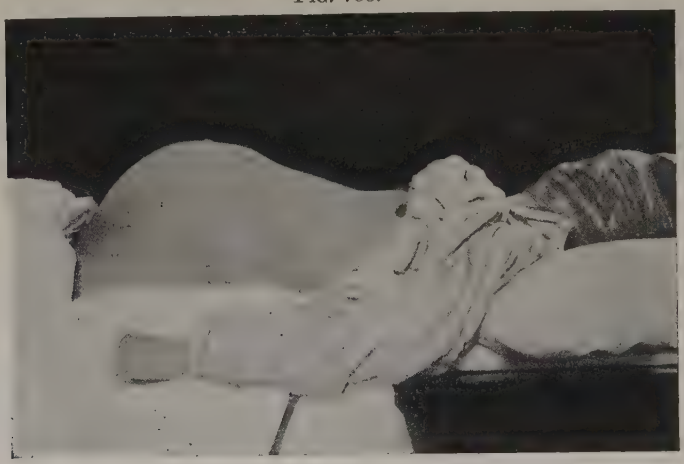
Fig. 787.

Fibroid tumor of the uterus. (Case of Dr. R. Abbe.)

The *immobility* of retroperitoneal and pancreatic tumors is characteristic. Tumors connected with the liver *move with respiration*, and sometimes those connected with the spleen will do so, while tumors of the kidneys, uterus, and ovaries do not. Any tumor in contact with the diaphragm or the liver will move downward on inspiration, but if the tumor is firmly held down by

the hand, it will follow the upward movement of those organs in expiration only when directly connected with them. This distinction is especially useful in ascertaining whether tumors of the stomach and intestine are free or adherent to the liver. Tumors connected with the intestine and stomach are more easily pushed up than drawn down, for by the latter movement

Fig. 788.



Fibro-cystic tumor of the uterus.

their mesenteric attachments are put upon the stretch. Tumors of the small intestine and sigmoid flexure are freely movable, while those of other parts of the colon are fixed. *Fluctuation* can be detected by laying one hand flat upon the abdomen and tapping the latter gently with the other at some distance. In persons with a very thick layer of fat upon the abdomen it is well to have an assistant hold a book or the edge of his hand firmly against the linea alba, in order to prevent a deceptive wave from crossing in the adipose tissue. **Percussion** will give the outline of many tumors, as they generally present areas of dulness or flatness. The relations of the tumor to the liver and the spleen may often be determined by this means. The presence of free fluid in the peritoneal cavity (*ascites*) is detected by percussing the abdomen while the patient lies on the back and marking the line of dulness caused by the fluid, and then turning him on his side and noting the change which occurs in the level of the fluid, as shown by the changing line of dulness, for the fluid naturally sinks to the most dependent part of the cavity. **Auscultation** is of little use in the examination of the abdomen.

Inflation and Injection.—Useful knowledge as to the relations of a tumor to the stomach or intestines is gained by filling those organs with fluid or air through a tube and studying by palpation and percussion the changes thus produced.

Digital examination by the vagina or the rectum should never be omitted, even when the tumor has apparently no relation to the pelvic organs. The entire hand may be passed into the rectum, but this method of examination is too dangerous for common use, and will rarely, if ever, be necessary. It is said, however, that a hand which measures ten, or cer-

tainly nine, inches in circumference may enter without danger of permanent paralysis or incontinence, and that although it produces lacerations in the anal mucous membrane, it will not rupture the bowel. The hand can be passed up to the sigmoid flexure, and the four fingers made to enter this part of the bowel, and then even the upper part of the abdomen may be reached by the fingers.

Exploratory puncture of the abdominal organs with the aspirating needle is a dangerous procedure. Death has occurred from hemorrhage from a needle puncture of the spleen, leakage of the fluid from a needle puncture of a hydatid cyst has produced fatal poisoning, and there is constant danger of infecting the peritoneum and setting up peritonitis by fecal extravasation through punctures of the stomach and intestine. The use of the aspirating needle should be limited to puncture of the peritoneal cavity and of the extraperitoneal surfaces of the abdominal organs.

Examination of Fluids.—The fluids obtained should be analyzed chemically and their sediment examined by the microscope. *Ascitic fluid* is clear and has a specific gravity of 1010 to 1015. It has a small amount of albumin, and partially clots on standing. It may contain fat-globules sufficient to give it a milky color, due to rupture of a lacteal vessel or to fatty degeneration of cells in malignant tumors. If peritonitis is present the fluid is cloudy, of higher specific gravity, contains more albumin, and also leucocytes and endothelial or pus cells. Ascitic fluid is often found when there are tumors in the abdomen, and if the latter are malignant it is apt to contain blood. The masses of endothelial cells, once considered a characteristic sign of an ovarian cyst when ascitic fluid occurs with an abdominal tumor, simply indicate irritation of the serous membrane, and are to be seen with any large tumor. The fluid of an *echinococcus cyst* is similar, especially if it be infected, but it has no albumin in its normal state, and contains larger amounts of mineral salts. Occasionally hooks or fragments of cyst membrane are found, and then the diagnosis is certain. *Ovarian cystic fluid* has a specific gravity of 1010 to 1024, but it may be less or greater. It may be thin or mucoid, or even colloid, and of various shades of yellow, green, or brown. Paralbumin is a characteristic constituent, and cylindrical epithelial cells and cholesterin crystals are common. *Hydronephrosis* furnishes a clear fluid, specific gravity 1010 to 1020, seldom containing albumin or cells unless inflammation has set in. The fluid from *fibrocystic tumors* of the uterus is yellowish, specific gravity 1020; it forms a clot at once, and contains no cells except a few leucocytes. *Pancreatic cysts* furnish a brown alkaline fluid which has power to digest fat and starch.

Conditions resembling Tumors.—**Ascites.**—Fluctuation is obtainable when there is much fluid. When the patient lies on the back there will be dulness on percussion in the flanks and perhaps at the pubes, but the central portion of the abdomen will be resonant, whereas in ovarian cysts the dulness is in the median line rising from the pubes, and the flanks are resonant. We have sufficiently explained the means by which free fluid may be recognized. A very thick layer of **abdominal fat** may simulate a tumor, but when the patient lies down and lifts the head and shoulders so as to fix the abdominal muscles, the mass of fat can still be freely moved

about, showing that it is external to the muscles. An accumulation of **fat in the omentum** or **mesentery** is not so easily distinguished from a tumor, but rarely forms well-defined masses. **Tympanites** is unlikely to be mistaken for a tumor, but its existence frequently masks the presence of the latter. An error due to a **distended bladder** is easily eliminated by the passage of a catheter. **Fecal masses** in the intestine are deceptive, but they can generally be recognized by their doughy consistency, which allows them to be moulded between the fingers, and in doubtful cases the administration of a purgative will clear up the difficulty. Some **hysterical** individuals have the power of imitating the presence of abdominal tumors by throwing the muscles into irregular contraction and forcing the distended intestine forward in tumor-like masses. It may be necessary to administer an anæsthetic before this condition can be excluded, for with the muscular relaxation of anæsthesia the so-called "phantom tumor" melts away. **Inflammatory masses**, consisting of adherent omentum and bowel and solid peritoneal exudate or encapsulated abscesses, often resemble neoplasms of the abdominal organs, but can be distinguished from them by the history of some previous inflammatory condition. Inflammatory masses, as a rule, are fixed to the abdominal wall at some point; they are not so distinctly outlined as the neoplasms, are more irregular in shape, not so hard, and are tender to pressure. We have, however, seen a small abscess surrounded by omentum which was freely movable in the abdomen, and such movable abscesses are not uncommon in tuberculous peritonitis. **Cold abscesses** often simulate neoplasms in the abdomen or pelvis, and when a fluctuating tumor is found in the lumbar or the iliac region, the spine, the pelvic bones, and the hip-joints should be carefully examined, for evidence of disease there will indicate that the mass is an abscess. **Enlarged mesenteric glands** may be taken for other tumors, but their fixed median situation and multiple or nodular character should reveal their nature.

Diagnosis of the Organ affected.—The most important thing to be determined about a tumor is its origin. The situation which it occupies, and its attachments to the liver, stomach, intestines, uterus, or other organs, must be carefully studied by palpation and percussion, for in the majority of cases the tumor originates from the organ to which it is attached. But the fact that any organ may be displaced from its natural position should never be overlooked, for a floating kidney or spleen might present itself as a tumor in the pelvis, and search must be made to prove that the organs are normally situated. In addition to the facts already given, the following points will be of assistance in the diagnosis.

Tumors of the **anterior abdominal wall** lie very superficially, and are movable when the abdomen is relaxed, but instantly become fixed if the abdominal muscles are made tense by causing the patient to lift the head and shoulders as he lies on the back, or by making him cough.

Tumors of the **stomach** are very difficult to palpate, as they generally lie well up under the ribs or the border of the liver, but they become more evident if the stomach is distended by food or by air or water. A tumor at the pylorus moves downward and to the right with distention of the stomach. Occasionally, however, a tumor of the stomach is found low down in the ab-

domen, owing to displacement or dilatation of the organ. Tumors of the **spleen** are more or less freely movable, and usually retain the shape of the organ, being flat and sharp-edged and having the splenic notch well defined upon the inner border. Tumors of the **gall-bladder** maintain intimate relations with the liver, and usually form pear-shaped cystic swellings lying in the normal position of the organ or extending downward. Tumors of the **liver** are continuous with that organ, as shown by palpation and percussion, whether they uniformly enlarge the liver or project from its border, and they move with respiration. They may be cystic or solid, and the surface may be smooth or nodular, being usually the latter when the enlargement is due to gumma, cancer, or hypertrophic cirrhosis.

Tumors of the **kidney** are lateral and extend into the loin, so that pressure of the hand in that region is transmitted to the palpating hand in front by the intervening tumor. The tumor usually preserves the shape of the organ, and in its early stages is somewhat movable, although it does not move with respiration. A loop of the colon lies in front of the mass, where it can be felt, or may be demonstrated by percussion when distended with gas. The tumor is usually firm or tense, and may have a smooth or a bosselated surface. Urinary symptoms may aid in making the diagnosis. For tumors of the **female genitals** we refer to the chapter on those organs.

Certain tumors develop in the **omentum** and **mesentery**, cysts being rare in the former and the tumors generally being sarcomatous, while in the mesentery cysts and lipomata are the most frequent. The cysts may be chylous if they are caused by rupture of a lacteal vessel, serous if they are of lymphatic origin, or hemorrhagic. Fatty tumors and sarcoma, as well as masses of glands, may also develop in the retroperitoneal space. Tumors of the omentum lie in front of the intestine, and may be fixed or movable. They lie above the pelvis, but are separated from the liver by the large intestine, and differ in shape from tumors of the spleen. These tumors are less easily drawn down than up, but they move with respiration. Tumors of the mesentery resemble tumors of the kidney in that they frequently have a loop of bowel crossing in front of them, but they lie in the middle line, and are much more movable than renal tumors until they have reached a large size. Mesenteric tumors do not follow the respiratory movements.

Retroperitoneal tumors (excluding tumors of the kidney and of the pancreas) lie near the middle part of the abdomen and are fixed in that situation. They are more difficult to identify than tumors of the omentum and mesentery, and are frequently confounded with tumors of the kidney or of the pancreas. The retroperitoneal tumors may be sarcomata, originating from the bones of the spine or the pelvis.

Tumors of the omentum offer the best prospect for operation, and may be extirpated after multiple ligation. Tumors of the mesentery are usually benign, and unless they are well encapsulated cannot be removed without great danger to the intestines, on account of the liability of damage to the mesenteric vessels, so that the operation should generally be limited to an exploratory laparotomy. Cysts, however, may be secured in the abdominal wound and drained. The retroperitoneal tumors (excluding renal and pancreatic tumors) are generally inoperable.

HERNIA.

A hernia is a protrusion of any of the viscera from the cavity in which they are contained through an opening in the wall of that cavity. The word "hernia" standing alone is generally understood to refer to protrusions through the deeper parts of the abdominal wall, but still covered by skin, a condition commonly known as "rupture," and we shall so understand it. The term is limited by some authors to a protrusion through an anatomical gap in the abdominal wall.

When one of the abdominal organs, a loop of bowel, or the omentum protrudes through the abdominal wall, it stretches some or all of the layers of the latter, and usually carries before it a pouch of peritoneum which surrounds the protruding part on every side. The peritoneal pouch is called the **sac** of the hernia, and its narrower part, where it passes through the opening in the abdomen, is called the **neck**.

When the contents of a hernia can be returned to the abdominal cavity the rupture is said to be **reducible**, the term **irreducible** being applied to the opposite condition. An **incarcerated** or **obstructed** hernia is one which was previously reducible, but has become irreducible, with symptoms of intestinal obstruction. A **strangulated** hernia is one in which not only is the passage of feces through the protruded bowel interrupted, but the circulation of the blood in the contents of the hernia is also impeded by a constriction at the neck of the sac or within the latter.

Etiology.—The causes of hernia are not fully determined. The umbilicus, the inguinal and femoral rings, and to a lesser degree the sacrosciatic notch and the obturator foramen, remain partially open until late in fœtal life, and sometimes even until birth, because they give issue to important parts, and if the closure of these openings is delayed or incomplete they afford an opportunity for hernia. The funicular process leading into the tunica vaginalis may remain patent without the formation of a hernia, and there is no evidence to prove that imperfect closure is necessary for its occurrence. The influence of violent muscular exertion in the production of hernia is generally recognized, but many authorities deny that it is possible for any effort to cause an immediate protrusion through the normal openings if properly closed, and they assume that when the hernia suddenly appears after a severe effort there has been some congenital deficiency at that point. An indication of the effect of muscular exertion is seen in the frequency of hernia among persons engaged in laborious occupations and in women during the child-bearing period. In pregnancy there is the additional complication of the stretching and subsequent atrophy of the abdominal walls. It is doubtless from the constant straining in micturition that a narrow foreskin and rupture are so often associated, and urethral stricture, habitual constipation, and pulmonary diseases with persistent cough result in the production of hernia for similar reasons.

An abnormally long mesentery is frequently found in cases of hernia, but it is uncertain whether this elongation is a cause or a consequence of the protrusion. The subperitoneal fat at the inguinal and femoral rings is often massed into a considerable tumor, to which the name properitoneal

lipoma has been given, and this mass may grow outward and make traction upon the peritoneum, forming a peritoneal pouch, which is said to predispose to the formation of hernia. These pouches, however, may exist without any hernia, and hence the efficiency of this cause is doubtful. Scars situated in the abdominal wall tend to the production of hernia by the stretching of the cicatricial tissue. Heredity appears to have a very decided influence upon the occurrence of hernia, and, according to Macready, ruptures in the grandparents are of more importance than those in the parents, especially for the occurrence of the congenital varieties. The number of males affected with hernia is about six times as great as that of females, doubtless owing to the frequency of inguinal hernia and the impossibility of the complete closure of this canal in the male. Hernia often accompanies retention, malposition, or delayed descent of the testicle.

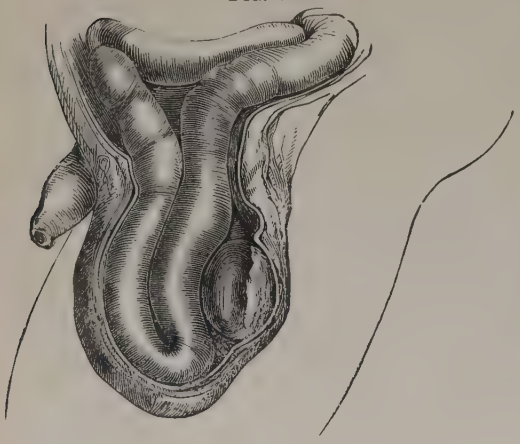
Hernia is exceedingly common in infants under one year of age, very rarely appears from infancy to puberty, at puberty again becomes common, and this proportion remains about the same until late in life. Although the total number of cases of hernia observed in elderly persons is less, the occurrence of hernia in the aged is relatively just as frequent as earlier in life, for the total number of old people in the population is proportionally less. It is true that the fibrous tissues are lax and the fat is absorbed in advanced age, so that the abdominal wall is decidedly weakened, but elderly persons are less subject to severe muscular effort and the other mechanical causes which produce hernia. The freedom of early childhood from hernia is supposed to be due to similar reasons, children not making the violent efforts necessary to produce the trouble, and hernia appearing in them only when there is a congenital weakness of one of the abdominal openings.

Varieties.—The different anatomical varieties of hernia are named from the openings through which they escape, the inguinal being by far the most common, and next being the femoral and the umbilical. Hernia also occurs through the obturator foramen, the sacro-sciatic notch, and the diaphragm. Congenital deficiencies or weak places occasionally exist in other parts of the abdominal wall where hernia may afterwards develop, these herniæ and those which come through cicatrices being known as ventral herniæ.

Inguinal Hernia.—Inguinal hernia is nearly twelve times as frequent as femoral, and is much more common in men than in women, the proportion being ten to one. In women, however, inguinal and femoral herniæ occur with equal frequency. There are several varieties of inguinal hernia. When the testicle has descended into the scrotum, the peritoneal canal may not close in the normal manner, and different forms of hernia depend upon these variations. When the canal remains patent in its entire length and a hernia takes place, its contents pass down into the tunica vaginalis and are in contact with the testicle, a condition known as **congenital hernia.** (Fig. 789.) The adjective "congenital" refers to the anatomical condition and not to the hernia, for the latter may not appear until late in life. When the canal is obliterated near the testicle, remaining open above, a prolapse into it is called **a hernia into the funicular process.** (Fig. 790.) When the canal is only closed above at the internal ring and the tunica vaginalis extends up to that point, a rare variety of hernia may form, in which the protrusion pushes

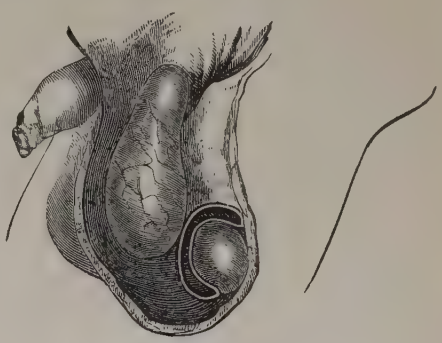
before it the closed end of the funicular process and invaginates it into the cavity of the tunica. A frozen section through such a hernia would show a true peritoneal sac to the hernia, surrounded by a double serous layer formed of the in-

Fig. 789.



Congenital hernia. (Agnew.)

Fig. 790.



Hernia into the funicular process. (Agnew.)

vaginated tunica. This condition is known as **encysted hernia.** (Fig. 791.) Different authors have given the name **infantile hernia** to both the funicular and the encysted form. The congenital and funicular varieties appear suddenly, and they are also characterized by a long and

Fig. 791.

Encysted hernia. (Agnew.)

Fig. 792.

Inguinal hernia. (Agnew.)

narrow neck where the funicular process has been partly closed, which renders them especially liable to strangulation.

When the inguinal ring closes in the normal manner, but a hernia develops afterwards, it is termed an **acquired hernia.** (Fig. 792.) The acquired varieties of inguinal hernia are two : first, the **oblique,** which descends through the inguinal canal, entering at the internal ring and passing out at the external ; and, secondly, the **direct,** in which the hernia enters a pouch of peritoneum, which is apt to form in the centre of the conjoined tendon just internal to the epigastric artery, pushes the conjoined tendon before it, and makes its way out at the external ring. A direct hernia may penetrate

the conjoined tendon instead of pushing it forward, and it may also be situated at the external border of the tendon in rare cases. An old oblique hernia often cannot be distinguished clinically from a direct hernia, because the dragging of the protruded bowel pulls the internal ring downward and inward in line with the external ring and destroys the obliquity of the canal, but anatomically the two are recognized by the situation of the epigastric artery, which lies internal to the neck of the oblique hernia and external to that of the direct. The distinction is of importance clinically, because an oblique hernia is much easier to retain by a truss than a direct. Congenital hernia is necessarily of the oblique variety.

An oblique hernia which has merely passed the internal ring and not the external and lies in the inguinal canal is known as an incomplete hernia or a **bubonocele.**

A hernia which lies in the substance of the abdominal wall is called an **interstitial hernia.** Interstitial hernia may be divided into properitoneal, intermuscular, and subfascial. In the **properitoneal** variety the sac is formed by a protrusion of the peritoneum, usually one of the natural pouches in that membrane, and makes a bed for itself in the extraperitoneal fat, between the membrane and the muscles. Strangulation may take place in such a sac. The sac of the **intermuscular** variety is formed by a protrusion which passes through the internal ring, and then leaves the inguinal canal by penetrating its walls without reaching the external ring, and makes its way into the substance of the abdominal wall between the muscles, usually lying between the internal and the external oblique. The **subfascial** hernia lies under the deep fascia. In these herniæ, especially the properitoneal form, the sac may be divided, and a part of it may lie in the canal and even reach the scrotum. In herniæ which pass into the canal through the internal ring, and then penetrate its walls and become interstitial, the strangulation may take place at the internal ring or at the opening through which they have left the canal. In the properitoneal form the sac and parietal peritoneum are closely adherent where they are in contact, and they can, therefore, be distinguished from a hernia which has been reduced *en masse.* Interstitial herniæ are usually situated near the inguinal canal, and their sacs may be directed towards the iliac fossa, towards the anterior wall of the abdomen, or inward towards the bladder. In the intramuscular form, the muscles over the tumor may atrophy and even disappear over a considerable area, and in these cases the peritoneal sac may turn upward over the abdomen, or downward over the anterior surface of the thigh, for having thus become subcutaneous it is no longer limited by the fascial attachments.

Relations of Inguinal Hernia.—As an inguinal hernia enlarges it descends into the scrotum in the male and into the cellular tissue of the labium majus in the female, and when it reaches a large size it may hang down to the knees. Double inguinal hernia is a very common occurrence. The relations of the cord to the neck of the sac in inguinal hernia are of considerable importance. The cord lies behind the sac in the majority of cases, but it may be spread out upon it, the vas deferens being always internal and the vessels external. Sometimes the protrusion appears to have passed directly through the tissues of the cord, separating the vas from the vessels. In con-

genital herniæ the cord may be quite prominent on the inner side of the sac, and may have a sort of mesentery. It would be natural to suppose that in direct herniæ the cord would lie on the external side of the sac, but it is frequently found on the inner side or spread over its surface, as if the protrusion had taken place through its tissues. The relations of the testicle to the sac are very variable. In acquired hernia the gland is usually found below and distinct from the sac, and in the congenital form it lies within the sac, but generally it can be found readily by palpation. The coverings of an oblique inguinal hernia when complete are the skin, superficial fascia, intercolumnar fascia, cremaster muscle (absent in the female), infundibular fascia, properitoneal fat, and peritoneal sac. In a bubonocele the external and internal oblique muscles take the place of the intercolumnar and cremasteric fasciæ. In a direct hernia the coverings are the skin, superficial fascia, intercolumnar fascia, conjoined tendon (sometimes absent), transversalis fascia, properitoneal fat, and peritoneal sac.

Femoral Hernia.—Femoral hernia issues by the femoral ring, is seldom as large as the inguinal variety, and is found in women three times as often as in men. It is not often as large as the fist, and is usually smaller than a hen's egg. It is much more liable to strangulation than the inguinal variety. The protrusion takes place between the femoral vein and Gimbernat's ligament, and presents in the upper part of Scarpa's triangle, but may be turned upward over Poupart's ligament. The coverings of the sac are the skin, the superficial fascia, the cribriform fascia, the sheath of the femoral vessels, the femoral septum, the properitoneal fat, and the peritoneal sac. The epigastric artery lies on the outer side of the neck, and the obliterated hypogastric artery on the inner side. There are rare forms which pass external or internal to these vessels, penetrate Gimbernat's ligament, or even issue external to the femoral vessels. In a certain small proportion of cases the obturator artery has an abnormal origin, passing above or anterior to the neck of the sac, and then descending along its inner border.

Umbilical Hernia.—Umbilical herniæ are of two varieties. One issues through the normal umbilical opening, and when it occurs at birth it may extend for some distance down into the substance of the cord, the vessels being expanded over its surface, forming a **hernia of the cord.** The **ordinary variety** breaks through the aponeurosis close to the edge of the umbilical ring, and occurs more frequently in later life. Infants of both sexes are equally liable to umbilical hernia, but in adult life it is most common in women over forty years of age, and especially in stout persons. The coverings of an umbilical hernia are merely the skin, the superficial fascia, the properitoneal fat, and the peritoneal sac, and they are generally very thin, with a tendency to ulceration and superficial sloughing. The omentum protrudes first into the sac, followed almost invariably by the large intestine, the omentum covering the bowel, and usually being adherent and irreducible. The tumor may be so small as to be scarcely perceptible, or it may attain an immense size, containing a large part of the intestine. The large herniæ are frequently obstructed, causing constipation and colicky pains. The smaller tumors are liable to strangulation, which pursues a more acute and fatal course than in other ruptures.

Ventral Hernia in the middle line close to the umbilical opening is not very rare. Similar protrusions in the **epigastric** region are peculiar in that they often consist merely of a little mass of the properitoneal fat, but in other cases there is a peritoneal sac which contains omentum or even intestine. Ruptures are also often found in the lineæ semilunares and in the lineæ transversæ, showing the tendency of these protrusions to take place through the fibrous parts of the abdominal wall rather than through the muscular. Hernia may take place through the substance of the muscles near the inguinal rings and simulate the ordinary inguinal rupture.

A separation of the rectus muscles produces a form of ventral hernia which is almost invariably found in women, especially after pregnancy. The separation may occur anywhere from the umbilicus to the pubes, and may extend the entire distance, giving exit to a large part of the abdominal contents and to the pregnant uterus. With this condition we may compare a congenital weakness of the linea alba occasionally seen at birth, extending from the umbilicus upward to the ensiform cartilage, but disappearing spontaneously as the tendon gains in strength and the child grows.

Lumbar Hernia.—Herniæ occur in the lumbar region through the triangle of Petit or immediately beneath the twelfth rib under the latissimus dorsi, where it covers the transversalis fascia. These herniæ are uncommon, but they sometimes attain a large size. There may be a congenital deficiency of the muscles of the abdomen at any part through which hernia may occur, with the ordinary characteristics of a ventral hernia. In one case observed by us in a young child, an opening as large as the palm of the hand was situated to the right of the umbilicus, and extended backward to the lumbar region. It became reduced to one-quarter of its size spontaneously as the child developed, and was then easily closed by operation.

Obturator Hernia.—Hernial protrusions may take place through the obturator foramen at its upper border, the relations of the obturator nerve and vessels to the neck of the sac being variable. These herniæ occur almost exclusively in women. They are of slow formation, and are very difficult of recognition, because of the small size of the tumor and of its situation in the deepest part of the thigh. The pressure of the tumor upon the obturator nerve occasions the so-called Howship-Romberg symptom, which is very useful in diagnosis—namely, the pain referred to the distribution of the obturator nerve on the inner side of the thigh and leg, and even reaching the great toe. Occasionally a paralysis of the adductor muscles supplied by the nerve has also been noted. Certain movements of the hip-joint may cause pain by the pressure of the obturator muscles upon the tumor, and tenderness may be detected by deep pressure in Scarpa's space. Examination by the vagina or by the rectum may aid in diagnosis by the detection of a loop of bowel adherent in that neighborhood. Obturator hernia is frequently complicated by inguinal or femoral hernia, and if symptoms of strangulation exist when the inguinal or femoral hernia is evidently not strangulated, search should be made for an obturator hernia.

Sciatic and Perineal Herniæ.—In rare instances hernia takes place at the greater or lesser sciatic notch above or below the pyriformis muscle, and the tumor may extend forward to the groin or upward towards the

trochanter. Occasionally the intervals between the muscular fibres of the levator ani give passage to protrusions which pass downward and present in the perineum, traversing the ischio-rectal space. In the male these are easily recognized, as they form a protrusion between the middle line of the perineum and the thigh, but in the female they may pass into the posterior or the anterior part of the labia, where they may simulate cysts. Such herniæ may also form protrusions into the vagina or even into the rectum. They are very rare and seldom strangulated.

Diaphragmatic Hernia.—Hernial protrusions occur through the diaphragm, entering the chest. They may be of traumatic origin and due to rupture of the diaphragm, and are then usually fatal. They may also be due to congenital deficiencies in the muscle, or they may pass through the natural openings in the diaphragm. In some cases the stomach and a large part of the small intestine has been found in the thorax and yet the patients have shown no symptoms of the displacement. The possible existence of such obscure herniæ should be considered in cases of intestinal obstruction.

Pathology.—The **contents** of a hernia are almost invariably omentum or intestine, although almost any of the abdominal organs may be found in unusual cases. The urinary bladder, stomach, ovaries, and uterus are occasionally met with, and even the spleen and the kidney when in the floating condition. A hernia containing omentum is known as an **epiplocele,** and one containing intestine as an **enterocele,** combinations of the two being called **entero-epiplocele.** The *omentum* may form a bag around the bowel, or may be displaced to one side of the sac. Omentum which has been long in a hernial sac undergoes hypertrophy of its distal part, owing to the venous congestion, and forms a mass like a lipoma, while the neck of the protrusion is apt to be reduced to a fibrous cord by the compression. The omentum may atrophy, openings appearing in it through which a knuckle of gut may become strangulated. In other cases calcification or cystic degeneration takes place, but the cysts which are most frequently seen in hernial sacs are due to chronic peritoneal inflammation, like those which form in the peritoneal cavity. Omentum is almost always adherent to the sac, at least at the neck, and an epiplocele is generally irreducible.

The *intestine* is much less likely to be adherent, and is usually very little altered by its sojourn in the hernia, but in some cases its walls are thickened, even to such an extent as to reduce its calibre. In some cases, instead of the protrusion of a loop of bowel, only a part of the circumference of the gut is protruded, being drawn out into a sort of pouch constricted at its base, a condition commonly known as **Littre's hernia,** although some contend that this name should be limited to a hernia of a diverticulum, and that this lateral hernia of the bowel should be called **Richter's hernia.** The lateral hernia may be due to the adhesion of the bowel-wall to the peritoneum which forms the sac, or to the omentum or other contents of the hernia being drawn down into the sac by their agency. This variety of hernia is not common, but it is very liable to strangulation, and the latter is difficult to recognize because the entire lumen of the bowel is not involved in the constricting ring, hence intestinal obstruction may be absent or incomplete. Littre's hernia is seldom found except at the femoral ring.

A Meckel's diverticulum or the appendix vermiformis may be found in a hernial sac, and in the case of these organs and of the Fallopian tube a peculiar form of strangulation, known as **retrograde strangulation**, may take place. This occurs when the base of the vermiform appendix or of the tube descends into the hernia while the tip remains free in the peritoneal cavity, and gangrene of the tip must result if the base becomes strangulated. When these organs are found in a hernia they should be drawn down and examined through their entire length before they are returned to the abdomen, lest peritonitis follow from perforation of the tip. The bowel in a hernia may be inflamed, it may be the seat of tuberculosis or of cancer, and perforation of the appendix may occur just as it does in the peritoneal cavity. Foreign bodies also occasionally find their way into the bowel contained in the hernial sac, and they may perforate the gut and its coverings, and escape externally, after the formation of an abscess.

The **sac** of a hernia may be a congenital pouch like that of the congenital inguinal or umbilical hernia, or it may be formed at the same time as the protrusion. In the latter case it is made by the sliding and stretching of the peritoneum in the neighborhood of the aperture through which the hernia escapes, as is shown by the folds and wrinkles of the membrane on the abdominal side. The sac is subject to certain changes. It may be divided into pouches either by bands external to it, especially in the femoral region by a band of the cribriform fascia, or by internal bands of organized peritoneal fibrinous exudate. When internal bands are present the sac is frequently found very much narrowed at the neck. This may be the result of inflammation, or it may be due to the natural attempt to close the funicular process at one or more points. The contents of the sac may be free, or they may become adherent owing to a chronic serous inflammation excited by the pressure of a truss or the impeded circulation. In some cases one of the extraperitoneal organs may be found in the sac, the cæcum, for instance, slipping down with the fat behind it, so that the peritoneal sac does not entirely include the bowel, that part of it which was extraperitoneal in the abdominal cavity remaining in the same relation to the sac. Such a condition as this, the presence of adhesions, or the hypertrophy of the omentum, already described, may prevent the return of the contents of the sac into the abdomen. Sometimes the neck of the sac becomes shut off by an adherent plug of omentum while the hernia is reduced, and serum accumulates in the empty sac and produces a *hydrocele of the hernial sac.* In some cases a sac with an obliterated neck has been pushed forward by another hernia developing behind it, a condition which must not be confounded with infantile or encysted hernia, although it may closely resemble the latter.

The **mechanics of strangulation** are not yet thoroughly understood. Strangulation may be the result of the descent of an additional loop of bowel into the hernia, for the narrow ring may be dilated as the loop passes, and may then contract by its elastic force around the small part of the loop. The obstruction to the passage of the contents along the intestine may be complete even when there is considerable space in the ring by the side of the bowel, and when a No. 10 English catheter can be passed down into the loop of gut. As the strangulated loop is shut off it becomes distended by

gas developing in it, by serum which transudes in consequence of the impeded circulation, or by additional fecal matter being driven into it from above. The effect of this distention is to draw more bowel down into the hernial sac, the expanding wall of the incarcerated loop pulling on the intestinal wall above, and this also draws down more mesentery into the ring and increases the pressure at that point. Complete obstruction to the passage of fecal contents and complete irreducibility may be present when the constriction is not tight enough to produce any mechanical disturbance of the circulation of the incarcerated loop. The first changes produced in the bowel by strangulation are venous congestion and œdema, followed by cessation of the circulation and finally by death of the tissues, which is apt to begin on the mucous membrane and extend outward to the serous surface. Before necrosis takes place, fibrin is thrown out on the peritoneal surface. Bacteria undoubtedly pass through the intestinal wall when the circulation is stagnant, and may cause inflammation and suppuration of the sac, but the exact conditions which favor their passage are not yet understood, as their outward movement seems to be independent of the duration and of the severity of the constriction.

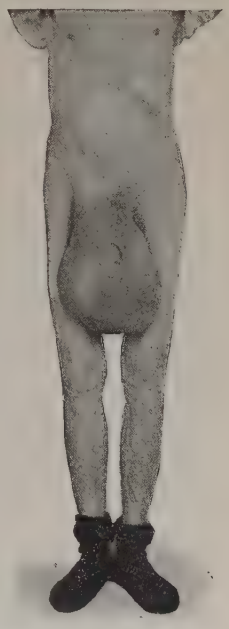
The constriction may be caused by the fibrous ring outside of the sac or by the neck of the sac itself, as the latter is apt to become narrowed and converted into a tough fibrous band when the hernia has existed for some time. In rare cases the strangulation may take place *within* the sac, a loop of bowel slipping through an opening in the omentum, or being constricted by a diverticulum or a band of peritoneal adhesions. Strangulation is rarely seen in a hernia containing no intestine.

Symptoms.—The symptoms of a reducible hernia are the existence of the hernial swelling, occasionally local pain or discomfort, or merely a feeling of weakness, and a tendency to constipation owing to the obstruction to the bowels caused by their protrusion. The tendency of a hernia is to increase in size, the ligamentous structures about the neck of the sac stretching and more of the abdominal contents being constantly prolapsed. The beginning of the formation of a hernia has sometimes been marked by pain in the groin, the testicle, the back, or the abdomen before any protrusion has been noticed. In children a rupture even of large size may leave no trace after reduction, and it may be difficult to prove that the ring is larger than normal, so that two surgeons examining the child on different occasions might give opposite opinions as to the existence of a hernia. Inguinal and femoral herniæ are more common on the right side. A very large scrotal hernia draws on the skin in all directions, even depriving the penis of its covering, so that the organ disappears under the skin, leaving at its normal situation a depression which looks like the umbilicus. (Fig. 793.)

The hernial tumor varies in size from a scarcely perceptible swelling to one twice the size of a man's head, the largest being of the umbilical and inguinal varieties. The tumor is covered with normal skin not adherent to the sac, but the skin may be very thin, or ulcerated by the pressure of a truss or bandage, large portions sometimes sloughing, with great danger of infection of the contents from the resulting suppuration. The tumor may be soft and compressible; or firm or doughy if it contains omentum or if the

bowel is filled with fecal matter; or it may be tense if there is any constriction at the ring. It often disappears spontaneously, or at least diminishes in size, when the patient lies down. There is a distinct impulse to be felt in the swelling when the patient coughs. **Impulse on coughing** is easily obtained in a large hernia by grasping it with the hand and directing the patient to cough, when an expansile distention of the sac will be felt. In a bubonocele it is recognized by invaginating the scrotum and passing the finger into the inguinal canal, so that when the patient coughs the impulse of the tumor will be felt against the tip of the finger; but this impulse must not be confounded with the contraction of the muscles around the invaginating finger. Scrotal herniæ when weighed in the hand are light, the swelling is soft and compressible, and fluctuation is seldom present unless there is free fluid in the sac. If the hernia includes bowel containing gas, resonance on percussion is evident. When the hernia is reduced the contents slip back rather suddenly, and are generally easily kept back by pressure over the ring. When the hernia is very small only an indefinite swelling may be felt, no distinct tumor being detected, and yet when pressure is made a sense that something yields and slips back, as in the reduction of a hernia, will enable the diagnosis to be made. The hernial swelling is not translucent, with rare exceptions in children. It is usually pyriform in shape, but the neck is rather thick and can be traced directly to one of the hernial openings. If the hernia is allowed to return after reduction, the swelling can be seen to begin above and to descend towards the bottom of the scrotum, and the patient will often say that the swelling appeared first in the groin and descended later into the scrotum.

Fig. 793.



Large double inguinal hernia. (Case of Dr. R. Abbe.)

If the protruded bowel becomes clogged with fecal matter the passage of the latter may be completely arrested, and the hernia is said to be **obstructed** or **incarcerated.** If the rupture has been previously reducible its contents can no longer be returned, and the tumor grows tense, painful, and may show signs of beginning inflammation. The impulse on coughing is lost. Absolute constipation exists after the intestine below the hernia has been emptied, and vomiting begins, assuming a fecal character later. Tympanites develops in the tumor and in the abdomen. The first symptoms are those of subacute intestinal obstruction, and if not relieved they are soon succeeded by those of strangulation.

When **strangulation** takes place there is severe pain; vomiting begins early, is apt to be violent, and soon becomes fecal; and the constipation is absolute, not even gas being passed by rectum. The patient is often severely prostrated, and the temperature may be subnormal. The hernial tumor becomes tense and tender, and the cough-impulse is lost. The tumor will be resonant on percussion if gas is present. There are often signs of

beginning peritonitis, such as tympanites and abdominal tenderness. The urine is diminished in quantity, and it is claimed that it contains albumin if bowel is included in the hernia. The symptoms are more acute in strangulation of bowel than in that of omentum, and a true epiplocele is seldom strangulated, a small concealed loop of bowel being generally found in cases supposed to contain omentum only. When **gangrene** of the strangulated loop has taken place, the pain ceases and collapse sets in, the apparent relief being so marked that the patient and his friends often imagine that the condition has been relieved.

Acute **inflammation** of the sac may be caused by perforation of the bowel. Acute inflammation is sometimes seen without strangulation, as the result of perforation of the bowel due to injury or ulceration. When inflammation occurs the hernial tumor is greatly swollen, the tissues become infiltrated, the skin red, and an abscess may develop in the connective tissue. In very rare cases recovery has taken place by the spontaneous discharge of the abscess and the formation of a fecal fistula at the opening. The inflammation may extend backward into the peritoneal cavity, setting up a general peritonitis.

If strangulation occurs and is not promptly relieved, death is almost inevitable, and takes place in from two to ten days. In neglected cases pneumonia may set in from the aspiration of vomited fecal matter into the lungs, inflammation may develop in the sac, or death may take place merely from shock or from the exhaustion of vomiting and intestinal obstruction.

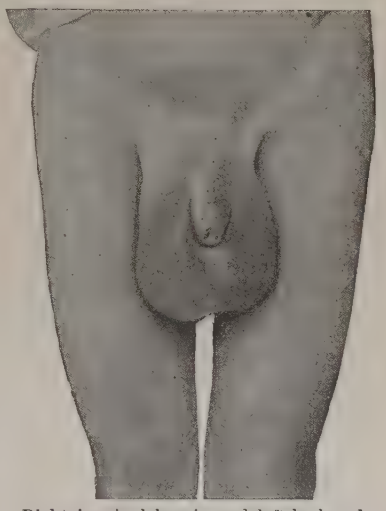
Diagnosis.—The diagnosis of hernia may be simple or very difficult. The principal conditions with which it is apt to be confounded are the various forms of tumor, especially enlarged lymphatic glands, tumors of the testicle or cord, lipoma situated over the femoral or inguinal rings, hydrocele of the tunica vaginalis or of the cord, cysts of Cowper's glands or of the vulvo-vaginal glands, and hydrocele of an old hernial sac.

The **tumors** which are liable to be mistaken for hernia are not reducible, have no impulse on coughing, are firm to the touch, and feel heavy when lifted in the hand; fluctuation is not usually detected, and there is no resonance on percussion. Tumors may be painful, and pressure may cause some increase of pain. Even if there should be a prolongation running up towards the groin the upper limit can generally be reached, and usually the tumor is more or less ovoid or globular. The patient will often relate that the swelling was first noticed in the lower part of the scrotum.

Hydrocele.—Hydrocele and cystic tumors may or may not be reducible according as the opening through the funicular process has remained open or not, but they are generally irreducible. If the hydrocele is reducible a distinct impulse on coughing may be present, and an imitation of this sensation is sometimes produced in an irreducible hydrocele when a prolongation of its sac extends well up into the inguinal canal, where it can be grasped by the abdominal muscles. Weighed in the hand, the hydrocele or cystic tumor feels of medium weight, but considerably heavier than a hernia. It is elastic to the touch, fluctuation is distinct, and there is absolute flatness on percussion. If reduction can be made, it is difficult to keep the sac empty by pressure upon the ring, for the fluid slips through under the

fingers. If reduction is allowed to take place spontaneously in such a hydrocele, by having the patient recline upon his back the reduction is very slow, while a reducible hernia under the same circumstances, when it once begins to move, usually slips back quickly. The hydrocele is almost invariably translucent, and hernia is very rarely so, the exceptions occurring in children, in whom the light sometimes passes imperfectly through a hernia. If the neck can be felt, it is generally thin, although we have seen some cases in which it was the size of the finger or thumb. The patient will generally state that the swelling was first noticed in the lower part of the scrotum. Hydrocele and hernia may coexist on the two sides. (Fig. 794.) As Macready points out, the method of distinguishing between congenital hydrocele and hernia by the greater ease with which the latter is retained after reduction is of little practical importance, because the diagnosis must generally be made in children, and in children a hernia when reduced is very apt not to return at once, even if the ring be large and the hernia of considerable size, and the test therefore cannot be applied. A congenital hydrocele, moreover, does not always come down at once after reduction. The diagnosis between hydrocele and hernia is less difficult than would appear at first, because irreducible enteroceles, which alone could be confounded with hydrocele, are rare, irreducible herniæ being usually omental. Hydrocele of a hernial sac is very difficult to differentiate from irreducible hernia except by its translucency and by exploratory aspiration. In women a hydrocele in the canal of Nuck is easily recognized, because a bubonocele in women is rarely irreducible.

Fig. 794.



Right inguinal hernia and left hydrocele, showing the difference in the neck of the tumors.

Varicocele.—The swelling of varicocele may be reduced by pressure, but without any sense of distinct slipping back. If the patient lies down the swelling becomes reduced, but very slowly, and it is not easy to keep it reduced by pressure upon the ring when the patient stands. The scrotum feels light, and the tumor has the characteristic sensation of a bundle of worms. No fluctuation is present, but there may be a decided impulse on coughing in certain cases, although the response is not quite so distinct as in a hernia or in a congenital hydrocele. When the neck of the sac is followed up towards the ring it is found to become very narrow, and the patient states that he first noticed the swelling in the scrotum.

An **undescended testicle** in the inguinal canal, when inflamed, is painful, and may occasion vomiting and simulate a strangulated hernia. It can be recognized by the absence of the testicle on that side and by the peculiar subjective sensation given by pressure upon the gland. An **inflamed testicle** is apparently often mistaken for a hernia, but such an

error can occur only from carelessness, the symptoms being very different. **Psoas abscess** may closely resemble a femoral hernia, especially as it may present an impulse on coughing and may be partly reducible, but it usually lies on the outer side of the femoral vessels. Fluctuation, moreover, is distinct, and another tumor can often be felt above Poupart's ligament, fluctuation being felt from one to the other. An examination of the spine or of the iliac bones will generally reveal the inflammatory origin of the abscess. A **varicose distention** of the upper part of the **saphenous vein** sometimes makes a protrusion in the femoral triangle resembling hernia, but it can be distinguished by the fact that it fills up from below when the femoral ring is completely occluded by strong pressure.

Diagnosis of the Variety of Hernia.—The aperture through which a hernia has descended is determined by tracing back the neck. In certain cases, especially in stout individuals, it is difficult to distinguish between inguinal and femoral rupture, and in every such case the position of the tumor should be disregarded and only the position and direction of the neck considered in making the diagnosis. In femoral hernia the neck must enter below Poupart's ligament, and when this landmark cannot be felt the pubic spine must be sought, and a straight line drawn from this point to the anterior superior spine of the ilium will nearly correspond to its course. The pubic spine can be readily felt in the male by invaginating the scrotum, and in the female by putting the adductors on the stretch and searching for the spine directly above their attachment to the pubes.

Suspected Strangulation.—In a doubtful case with symptoms resembling strangulation, any suspected swelling should be examined by an exploratory incision if necessary. The presence of obturator and sciatic herniæ in particular should be excluded before deciding that the strangulation is internal.

Treatment.—Hernia, whether reducible or irreducible, can be treated by applying apparatus to retain it or prevent its growth, or by operation, and a radical cure may be obtained by either method, although more certainly by operation. A spontaneous cure sometimes takes place in infancy, even without the aid of a truss, especially in inguinal hernia.

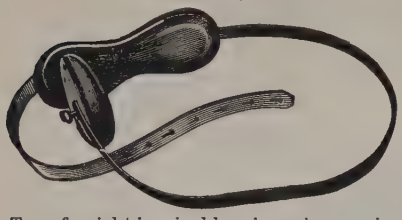
Trusses.—A truss is a form of apparatus applied to retain a reducible hernia or to prevent an irreducible one from becoming larger. In from one-sixth to one-fifth of the cases a complete cure may be obtained by persistent and intelligent use of a good truss, but a successful result is possible only when the hernia is entirely reducible, when the truss retains it perfectly, and when the rupture is never allowed to descend. Every time a hernia which has been retained by a truss passes through the canal it stretches the latter again and pushes down the sac, and the original condition returns. A cure by a truss can be hoped for only in inguinal hernia in the young and in umbilical hernia in infants. Trusses for inguinal and femoral herniæ are of three varieties, all of them consisting of two important parts—a pad to press upon the hernia and a spring which passes around the body to hold the pad.

The Pad.—In ordinary cases the pad should be broad and flat, for a conical pad forces its point into the canal and tends to enlarge the latter.

The pad may be circular or oval in shape. It is usually covered with soft leather and stuffed, or it may be a rubber sac filled with air or some fluid, but a simple pad of hard rubber or wood is also in use.

The Spring.—The spring is of several varieties. The first form passes around the body on the ruptured side, behind the back, and across to the opposite sacro-iliac articulation. (Figs. 797 and 798.) The second form of spring crosses in front from the ruptured side to the opposite and around the body to the sacro-iliac articulation upon the ruptured side, thus including about three-quarters of the circumference of the pelvis. (Fig. 795.) The third form is a spring which crosses the front of the body and is open behind, its two ends resting upon the sacro-iliac

Fig. 795.



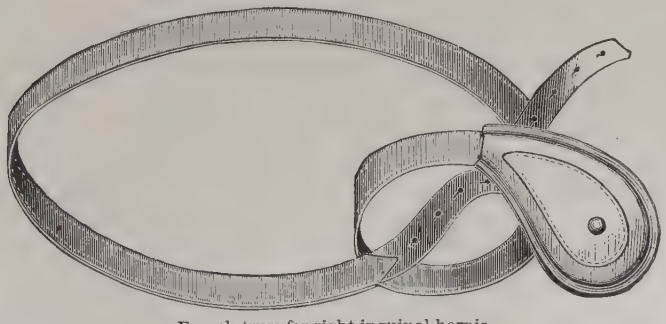
Truss for right inguinal hernia, spring crossing the body.

Fig. 796.

Double truss, spring open behind.

articulations (Fig. 796); or a spring which is open in front, passing around the body from behind and carrying a pad at each end, thus leaving the space over the pubes free. The third form is employed for double hernia. In both the single forms mentioned the spring is of a slightly spiral shape, the point of pressure at the back being decidedly above that at the femoral or inguinal ring, and the spring should lie about midway between the crest of the ilium and the trochanter. The spring is made of steel of low temper, so that it can be easily bent in the hands, and is covered with leather, hard rubber, or celluloid. The two latter must be dipped in hot water if it is necessary to alter their shape. The spring known as the French truss (Fig. 797) has little stiffness, but is shaped to fit the body exactly, and maintains

Fig. 797.



French truss for right inguinal hernia.

a continuous gentle pressure; while the German truss (Fig. 798) is very stiff, but does not fit very closely, and therefore simply resists when the hernia tends to descend against the pad. The strength of the spring must be suited to the individual case, a very light spring being usually sufficient if

the spring is properly shaped and applied, but in some cases a very heavy spring is necessary. The form of spring surrounding the ruptured side of the body is not quite so efficient as that which passes around the sound side, because its support in the back is on the opposite side and the pressure is not so direct, but it is easier to fit because it lies naturally in the fold of the groin, and is therefore very popular. A truss consisting of an elastic band with a pad is a favorite with some, but it is much less efficient and direct in its pressure than the spring trusses, and should be limited to use at night.

FIG. 798.

German truss for right inguinal hernia.

When the surgeon is fitting a patient with a truss he should reduce the hernia and press lightly over the point of exit while the patient coughs and makes various movements, in order to determine the amount of pressure which will be necessary to hold the hernia. Having selected a spring of the proper strength, the pad is applied over the point of exit, the spring is passed around the body, and the truss is secured by the strap. The patient again makes efforts of coughing and of stooping, to ascertain if the truss is efficient. But it should be remembered that a pressure that is readily borne for a short time may be sufficient to produce destructive changes in the skin at the point of contact if long continued; therefore the lightest possible pressure consistent with retention should be used in every case. It will frequently be impossible to put on a truss which will retain the hernia during coughing, and the patient must be directed to press upon the pad with his hand whenever he coughs. After the lapse of a few days or weeks, however, the truss will often prove sufficient to hold the hernia even during coughing, some contraction of the ring having taken place. In oblique inguinal hernia the pad should be placed directly over the internal ring, not over the external, nor over the neck of the sac still lower down. In cases of femoral hernia the spring must be twisted so that the pad shall press directly upward when the patient stands erect, as the femoral ring lies in a horizontal plane in that position. Even in inguinal hernia, when the patient has a prominent abdomen, the spring must be twisted so that the pad will press almost directly upward, and it is very difficult in such individuals to secure sufficient pressure to retain the hernia. In thin persons, on the contrary, the pad has a tendency to ride up on the abdomen, and must be held in place by a perineal strap, which should pass downward from the pad around the inner side of the thigh, and follow the crease of the buttock to the spring

at a point near the trochanter of the same side. In very large and old herniæ, particularly the direct form, or those which were originally oblique and have practically become direct, a large triangular pad is sometimes necessary, the lower apex being carried down between the scrotum and the thigh, and being continuous with the perineal strap. This form is called the rat-tailed pad, and while it is useful for herniæ of this kind it should not be employed in others, for it applies the pressure in the wrong place. It is easier to fit a double truss than a single one, and if, with a hernia on one side, the other side is weak, the patient should wear the double truss, preferably that form with pads at each end of a spring which encircles the body behind, and a strap connecting the ends in front.

Umbilical hernia in infants can be treated by a flat cork pad placed over the navel and held by adhesive straps, for no bandage will hold it properly. In older children and in adults a similar pad may be secured in the centre of a strong abdominal belt or of a strong spring passing around the body and resting on two wide pads on each side of the spine. As this hernia is apt to occur in very stout individuals, the level of the ring will be very much deeper than that of the abdominal surface, and a conical pad may be necessary in order to exercise proper pressure, but the apex of the pad should be so much larger than the ring that it cannot enter and stretch the latter.

The various kinds of truss described are suitable for reducible hernia. In the irreducible varieties it is almost impossible to apply an efficient pad, but sometimes a hollow cup-shaped pad may be used, being made to fit a cast taken of the irreducible part of the tumor, and this may be held in place by a spring or an abdominal belt. It will be found, however, that patients with irreducible scrotal or labial hernia are generally most comfortable with a cotton bag made of proper size to hold the hernia and exercise slight pressure upon it, and that those with irreducible ventral or umbilical hernia prefer a simple body bandage.

When an attempt is to be made to cure a hernia by a truss, the patient should have a lighter truss to wear at night, and should never go without the instrument, even when in the bath. In any case the patient should be instructed how to adjust the truss, and should be told to remove it at once if he feels the rupture come down behind it, for the pressure on the descended rupture is liable to do damage.

Injections into the Tissues of the Canal.—From time to time various other methods of treating hernia have been recommended, such as the injection of astringent applications along the canal or into the surrounding tissue, the best known and most used of these being absolute alcohol and a tannic acid solution. In making these injections the finger is placed in the canal as a guide, the needle is then made to pass along just outside of the fibrous tissues forming the canal, and the injection is made at this place. While cures can undoubtedly be produced in this way, the method is uncertain, and its application adds very much to the difficulty of any subsequent operation on the parts, whether the operation be practised on account of strangulation or to obtain a radical cure. If the fullest asepsis is not maintained, suppuration will follow the injection, and, unless the needle is accurately

guided, the fluid may be thrown into the peritoneal cavity: hence the method is not free from danger.

Operations for the Radical Cure of Inguinal Hernia.—Of the operative methods recommended for the radical cure of inguinal hernia it is unnecessary to describe more than five. To prepare the patient for operation the bowels must be thoroughly evacuated, and the pubes, scrotum, and labia shaved and sterilized as usual. The incision is to be a free one, thoroughly exposing the ring to be sutured, but it is unnecessary to make it the full length of the sac, as the latter will readily strip out of its loose cellular bed.

(1) **Czerny's Method.**—In this operation the sac is dissected out, ligated, and cut away, and the external ring closed by sutures.

(2) **Macewen's Method.**—Macewen improved upon this method by including the conjoined tendon in the sutures. He opened the sac, returned the contents, and bluntly dissected a space between the peritoneum and the abdominal wall as a bed for the sac. He next passed a continuous suture back and forth through the sac, entering at its lower end and coming out at its neck. The needle was then made to carry the end of this suture through the abdominal wall above the internal ring, the sac was crowded into the space previously dissected, being folded up by the suture, and the latter was secured to the skin. The conjoined tendon was then sought, and sutures passed between it and Poupart's ligament, thus reducing the size of the internal ring. The cord was allowed to remain close to the pubic bone at the lower end of the opening, and this was the weak point in the method, as a fresh protrusion easily descended along the cord as it passed directly through the abdominal wall instead of obliquely.

(3) **Bassini's Method.**—Bassini frees the sac, ligates it very high up, pulling it down so as to draw down the peritoneum on all sides in order that the peritoneum shall be gathered in at the neck of the sac by the ligature and present a perfectly flat, smooth surface internally, without any depression or pouch which might favor a recurrence. The sac is then cut away. The anterior wall of the canal is then incised up to the level of the internal ring, and the cord is drawn upward and outward so that it passes through the upper part of the wound; the conjoined tendon is then sutured to the internal surface of Poupart's ligament below the point where the cord passes through the abdominal wall, thus forming a posterior wall for the canal. The cord is then laid upon the sutured conjoined tendon, and the divided aponeurosis of the external oblique is united in front of it so that the normal oblique structure of the canal is very nearly reproduced.

(4) In **Halsted's method**, which is similar to Bassini's, the external wall of the canal is incised up to the internal ring, and the entire thickness of the abdominal wall is divided obliquely for an inch or more higher. The peritoneal opening into the sac is sutured. The muscular layers of the wound are united with mattress sutures, leaving the cord passing out of the upper angle. All but one or two of the veins of the cord are cut away to reduce its size. The skin is then united over the cord, which lies directly under it on the external oblique.

(5) **Kocher** recommends a method which leaves the canal intact but displaces the sac. Having exposed the sac and the external surface of the abdominal wall, he makes an opening through the external and internal oblique muscles above the internal ring, and passes through that opening a dressing forceps which is directed along the canal to the external ring and made to grasp the fundus of the isolated sac and draw the latter back through the passage made by the forceps. Then by strong traction the neck of the sac is brought to the level of the new opening in the abdominal wall and secured there by a couple of sutures. The sac is folded lengthwise and laid down along the course of the inguinal canal, but external to it, and is secured there by strong sutures, which draw a fold of the aponeurosis of the external oblique from each side over the sac. The internal ring is narrowed by a deep suture.

The most frequently used, and apparently the most efficient, of these operations is Bassini's. Personally we prefer Macewen's treatment of the sac combined with Bassini's suture of the canal, but the former is not always possible when the sac is very thin. In some cases a ligature cannot be applied, and it is necessary to suture the peritoneal opening.

In the Female.—All these operations can be performed in the female, but the round ligament should be included in one or more of the sutures passing through the conjoined tendon. It has been our custom in small herniæ to treat the ligament like the cord in the Bassini operation, but in ruptures with a large internal ring to secure it in the lower angle of the opening, as in Macewen's operation.

Injuries to the Bladder.—It is unnecessary to speak of the necessity of full aseptic precautions and the danger of cellulitis and peritonitis if they are neglected, but the danger of wounding the bladder in these operations should be emphasized. The sliding down of the peritoneum in the formation of the hernial sac is very apt to draw the extraperitoneal portion of the bladder into the hernia, and the structure of the organ is so altered that it is difficult to recognize it even when it has been incised, for it resembles a thin serous membrane or a mass of properitoneal fat. As the prolapsed portion of the bladder lies close to the neck of the sac, it may be included in the ligature or in the deep sutures. If in any case the peritoneum does not strip up readily on the inner side of the neck of the sac, or if the structure of the latter appears unusual in any way, the surgeon should not proceed until he is satisfied that the bladder is not involved.

Radical Operations for Other Herniæ.—Femoral Hernia.—The operation for the radical cure of femoral hernia is not so satisfactory as that for inguinal. The outer wall of the femoral canal is formed by the femoral vein, and no suture can be passed on that side. Two methods are in favor for the treatment of this form. In the first, which may be called the *purse-string method*, the sac may be pulled down and tied off as high as possible, or it may be doubled up and treated as in Macewen's method. The femoral canal is then held widely open by lifting Poupart's ligament by a blunt retractor, and a small curved needle threaded with silkworm-gut is made to pick up the under side of Poupart's ligament, Gimbernat's ligament, and the sheath of the pectineus. This suture is tied, and a similar suture is

passed through the same parts a little external to the first, the first stitch being invaginated by tying the second. A third suture may be passed outside of these. We have obtained very good results with this method, and the operation is not especially difficult. Another method may be called the *flap operation.* A flap is formed from the sheath of the pectineus muscle, or from the muscle itself, turned up under Poupart's ligament, and secured by sutures to that structure.

Umbilical Hernia.—The radical cure of umbilical hernia also is rather unsatisfactory, because of the difficulty of bringing the edges of the umbilical ring in contact on account of the great abdominal tension. The contents are usually adherent to the sac, and the latter must be opened with caution, for fear of wounding them. We have found it best first to open the abdomen just above the umbilical ring and then to pass the finger through into the sac and cut down upon the finger. In this way the adhesions can be released much more readily than if the sac were opened directly. When the adhesions have been separated and the omentum removed as far as possible, the remains of the sac are to be sutured across the opening. The edges of the umbilical ring are freshened, and if the circular opening is very wide a small wedge-shaped piece may be taken from the fascia in the middle line of the abdomen above and below, in order to form an oval opening, which is easier to suture. The edges are then brought into contact with silkworm-gut sutures, or, if the tension is very great, with silver wire secured to lead plates or buttons at the ends. The bowels and diet of the patient should be carefully regulated beforehand, in order to diminish the intestinal contents as far as possible, and to prepare against the danger of obstruction when adherent bowel must be returned. Relapses are very frequent after these operations, and the patients are apt to be stout and bear operations badly, but when the amount of disability is considerable an attempt should be made to obtain a radical cure. In **ventral hernia** following a laparotomy the old scar should be thoroughly excised, and the wound thus made closed as in an ordinary laparotomy without drainage.

General Considerations in Operations for Radical Cure.—Sutures.—The material used for the deep sutures in these operations is very various. Catgut is good, and the chromicized catgut can be made to resist absorption for five or six weeks. Kangaroo tendon, sterilized by boiling in alcohol, is said to last a couple of months, but we have known of cases in which it was absorbed in less time, even in three weeks. Silver wire is objectionable, as it may irritate the tissues by its hardness. Silk and silkworm-gut, especially the latter, make good permanent sutures, but they are liable to be sources of infection as foreign bodies later, and to cause small abscesses. It is true that the latter may be due to bacteria circulating in the blood and settling in the tissues irritated by the foreign body, but practically all these cases are caused by deficient sterilization of the material, a small amount of germs or spores being left in them which develop weeks or months after the wound has healed. It should be remembered that no permanent suture has any holding power after the wound has healed, and it is then invariably found lying loose in its bed, so that its use does not add

to the strength of the parts. Probably the best materials are kangaroo tendon and chromicized catgut.

Results.—The results of these operations are best in oblique inguinal hernia of moderate size, in which at least three-quarters of the cases may be guaranteed a cure by Bassini's method. The success will depend upon the aseptic healing of the wound, and even a superficial suppuration is liable to be followed by a recurrence. While the majority of relapses take place within a year, no case can be considered a certain cure until from three to five years have passed without recurrence.

Contra-indications.—The operation for the radical cure of hernia should be undertaken only under favorable conditions of health and strength, as it is an operation of choice. We have operated in cases of phthisis of moderate degree and chronic bronchitis, in which the hernia was troublesome on account of the patient's cough, and obtained a good result. The presence of cough during convalescence, however, jeopardizes the success of the operation. Obesity, renal disease, and great size of the hernia are also contra-indications. In the last case a course of preliminary treatment, consisting of rest in bed, attention to diet and bowels, and keeping the hernia reduced by a truss or bandage, is essential. In these large herniæ the abdomen contracts when the hernia has been unreduced for a long time, and if operation is undertaken at once there may actually not be room in the cavity for the extruded organs. Even if the hernia cannot be entirely reduced before the operation, owing to the presence of hypertrophied omentum, a partial reduction may accustom the abdomen to retain the bowel which has been contained in the hernia, and the bowel can usually be returned, while the return of the omentum is of less consequence, as the latter can be removed at the time of operation.

After-Treatment.—During the after-treatment it is all-important to secure early and regular evacuation of the bowels, especially if there is a rise of temperature or any tympanites, as these are more likely to be troublesome than after ordinary laparotomies. If the wound is infected, as shown by fever, tenderness, and swelling, the superficial sutures are to be removed. The deeper ones may be allowed to remain if the wound is kept open by packing, so that they are in sight and can be watched, but they must also be taken out if the symptoms continue or if pus is produced. The patient should be kept lying down for at least three weeks, and in cases of umbilical and ventral hernia should wear an abdominal bandage for a year. All violent effort must be forbidden for several months, but gentle muscular exercise will strengthen the parts and should be encouraged.

With the exception of the use of an abdominal bandage in cases of umbilical and ventral hernia, a truss should not be worn after these operations, as the pressure of the pad is apt to cause atrophy of the parts. A truss should be applied, however, at the first sign of a recurrence. Even if a permanent cure is not obtained, such an operation as Bassini's often enables a light truss to hold herniæ which were formerly uncontrollable.

Treatment of Strangulated Hernia.—Taxis is the manipulation employed to reduce a hernia. It consists of a steady pressure made upon the contents of the sac, while the fingers of the other hand exercise gentle

stroking movements towards the aperture of the sac along the neck. The patient must be so placed as to lessen the amount of traction and compression of the ring. Thus, in inguinal and femoral hernia, and in obturator hernia also, the thigh should be flexed upon the pelvis and rotated inward. In umbilical hernia the back should be bent forward by pillows under the shoulders and the hips, in order to relax the abdominal muscles. The recumbent position should always be employed, and in some cases it is of advantage to place the shoulders lower than the pelvis. The greatest gentleness should be exercised in taxis, in order to avoid injury to the bowel, especially when strangulation exists, for when the intestinal circulation has been impaired the gut is likely to be much softened. After the contents of the hernia have been reduced it is sometimes possible to reduce the sac also, the attachments of the latter by loose cellular tissue being so light as to enable one to invaginate it and return it to the abdomen. In applying taxis it should be remembered that the part which has come down last should be the first to return, and that this part will generally be found at the back of the sac, and therefore the fingers should be made to press upward along this part. As the patient lies upon his back, the sac should be elevated, in order to bring the contents more into line with the canal, and it is sometimes of advantage to lift the hernial tumor vertically, so as to have the aid of gravity in the reduction. In femoral hernia, when there is a tendency of the sac to roll upward towards Poupart's ligament, as is often the case, the tumor should be drawn down during taxis. The surgeon should place his fingers underneath the sac and his thumb in front of it, and the fingers should make regular kneading movements upward. If more force is necessary in large ruptures the sac is grasped in both hands, the fingers being behind and the thumbs in front, while the wrists steady the neck of the sac and make lateral pressure to force the parts into a funnel shape with the apex directed towards the ring.

An anæsthetic is of great assistance in the reduction of a strangulated hernia, many ruptures which have previously resisted persistent efforts being reduced with ease when full muscular relaxation is obtained. But it is undesirable to administer the anæsthetic often, and therefore the patient's consent to immediate operation should be secured before it is given, and the necessary preparations must be made in order that the operation may be undertaken at once when a five minutes' attempt with the taxis fails. If there is any objection to the use of an anæsthetic, the well-known methods of applying ice-bags or an ether spray to the tumor, or allowing ether to evaporate from a cloth laid over the rupture in order to contract and empty the blood-vessels, will sometimes be of service. Partial muscular relaxation may also be obtained by placing the patient in a hot bath. But the anæsthetic is to be preferred to all other adjuvants of the taxis, because the employment of others causes the loss of valuable time, and to be successful both taxis and operation must be carried out at the earliest possible moment. Before the anæsthetic is given the patient's stomach should be washed out, lest vomiting take place while he is unconscious, and pneumonia be set up by aspiration of vomited material.

Sometimes the symptoms—vomiting, constipation, and abdominal pain—

are not relieved even when the hernia has apparently been successfully reduced, a condition which may be the result of peritonitis caused by perforation of the bowel, of paralysis of the affected loop of bowel from long-continued pressure during the incarceration, of reduction in mass, or, finally, of the presence of another hernia. If peritonitis develops, the abdominal pain will become more marked, there will be a rise of temperature, and tympanites will appear. If the incarcerated loop is paralyzed, tympanites and constipation will be the chief symptoms, and they may be relieved by the administration of a mild laxative or of high enemata; but if the patient's strength is failing, the abdomen should be opened at once, in order to ascertain the condition and to correct it if possible.

Accidents in Taxis.—If too great force is used in taxis it is possible to rupture the sac just beyond its neck and force the contents into the space between the peritoneum and the muscles of the abdominal wall, or, the sac remaining intact, both the sac and its contents may be forced through the ligamentous ring into this space, the constriction of the neck of the sac continuing as before. This is termed *reduction in mass* (*en bloc*), and has serious consequences, the real strangulation not being reduced. If there is a suspicion that this accident has occurred, the usual gurgling at the moment of reduction being absent, it may be verified by finding a tumor in the abdomen in the neighborhood of the ring which is formed of the contents of the sac, and by the continuation of the symptoms with unabated intensity, the pain in particular being increased. In such cases the tumor must be cut down upon immediately and the seat of the strangulation sought. This may be in the neck of the sac, the entire sac having been forced into the abdomen, together with its contents. The strangulation may be due also to the incarceration of the bowel in an aperture in the omentum, or to the pinching of the gut by an intestinal diverticulum or adhesion, and although these cases are rare they are probably more common than a true reduction in mass. Multiple herniæ are not unusual, and there may be more than one irreducible hernia in the same individual, so that the wrong hernia may be operated upon, the strangulated one remaining undiscovered, especially if it be of the obturator or sciatic variety, for the local symptoms of tension and tenderness are somewhat uncertain. Internal strangulation or intestinal obstruction may also coexist with an irreducible hernia, and would naturally be unrelieved by an operation on the latter.

Contra-indications to Taxis.—In certain cases taxis is contra-indicated, and herniotomy should be undertaken at once. If there is evidence that the hernia was irreducible before the strangulation took place, taxis should not be attempted. If there is any reason to fear that the vitality of the bowel is impaired, because the strangulation has been very acute, as shown by severe pain, violent emesis, and great prostration, or because the symptoms have lasted more than forty-eight hours, no attempts at reduction should be made, as they might easily cause perforation of the bowel and a fatal peritonitis. Immediate operation is also demanded if there are local signs of inflammation, such as redness, œdema, or indications of sloughing.

Operation for Strangulated Hernia.—Reduction of the strangulated

bowel may be undertaken from the abdominal side either by sinking the hand deeply into the abdomen by depressing its wall and catching the bowel or omentum where it can be felt to pass into the internal ring, or by inserting the finger in the rectum. It has even been suggested to perform a laparotomy and pull the bowel out from above, but this method has never been generally accepted, because it does not allow investigation of the condition of the bowel before it returns to the peritoneal cavity, nor does it permit the division of any constricting bands or adhesions at the neck of the sac. Obturator hernia, however, may be treated in this manner, as the external operation is very difficult in that variety of hernia. The **old operation** for strangulated hernia, or **kelotomy**, in which the sac was left unopened, is now little used, being limited to extreme cases in unfavorable surroundings where more thorough measures are impossible. An incision is made over the neck of the sac, exposing the latter and the ring. It may be very difficult to recognize the sac, and it is seldom possible to distinguish the usual anatomical "coverings," as the tissues are apt to be matted together and inflamed. The sac is recognized by its dull white or translucent color and the arrangement of its fibres and vessels in longitudinal lines, which is quite different from the circular course of the vessels of the bowel. When these parts are exposed a blunt-pointed bistoury is inserted under the edge of the ring, and the latter enlarged by very small incisions, and then the contents of the hernia are to be reduced. If this cannot be done, the sac must be opened, and the contents drawn down and examined, and if no other point of obstruction can be found the neck of the sac must be still further enlarged. In the case of inguinal or femoral hernia the constricting ring may be divided directly forward or upward, the blade of the knife being held parallel with the median line. This incision must be made as shallow as possible, to avoid wounding blood-vessels which may cross the neck, especially in the case of femoral hernia; therefore the knife should be very dull, and it is better to make several shallow incisions than a single deep cut. If the protruding loop of bowel is small, it should be held down while the stricture is being divided, lest it slip up before a thorough examination of its condition can be made.

Modern Operation.—Surgeons now open the neck of the sac at once and examine the contents, especially if violent efforts of taxis have been made or if the strangulation is severe or has lasted over twenty-four hours. The constriction is then relieved in inguinal hernia by open incision of the canal, but in femoral by nicking the ligament as just described. If the patient's condition is good and the hernia can be reduced, the operation is concluded by suturing the opening, as in one of the methods of radical cure.

The **treatment of the contents of the sac** will depend upon their condition. If they are perfectly natural, they are returned to the abdomen. If they are doubtful, a delay of a few minutes will often decide the question, for when relieved of the constriction they rapidly regain their color. There is usually considerable serum in the sac, often with a fecal odor, but unless cloudy it need not prevent the return of the strangulated bowel. A free escape of serum upon opening the sac may be looked upon as a good sign

as to the vitality of the gut, for it protects the bowel from injury during attempts at taxis, and by its pressure probably decreases venous congestion, thus diminishing the risk of gangrene. If omentum is found in the sac, it should be resected, a ligature being placed around its narrow neck; but it should be carefully examined in order to avoid injury to any small loop of bowel which may be enclosed in it. If the intestine is dark purple or of a whitish-gray color, it must be considered suspicious, and especial care must be taken in examining the narrow part of the bowel lying directly under the constriction. There is no certain sign of viability, for dark-colored gut has recovered, and gut which bled freely has sloughed after reduction. Free separation of the peritoneal coat indicates sloughing. In doubtful cases the intestine may be left lying in the wound lightly covered with gauze for from six to twenty-four hours, until the surgeon is certain of its viability. If it is evident that the intestine cannot live, it is generally best to make an artificial anus by attaching the intestine loosely to the edges of the ring with peritoneal stitches, so as to shut off the peritoneal cavity, and incising the most dependent part of the loop, which should be left in place until adhesions have formed, when it can be cut away. If the patient's condition is good, however, and the surgeon is trained in intestinal surgery, the affected loop of bowel may be resected and the ends united at once by sutures or by Murphy's button, the latter being the more rapid method. But even with the greatest skill there is danger of infection of the peritoneum by the sloughing bowel. For the details of the resection we refer to the chapter on intestinal surgery.

CHAPTER XXXV.

SURGERY OF THE ANUS AND THE RECTUM.

Wounds of the Anus and the Rectum.—Wounds of the anus and the rectum are comparatively rare accidents, by reason of the protected position of these parts, but may occur from bodies thrust into the anus or through the skin of this region, or from pins, needles, pieces of glass, shell, bone, or other hard substance which have been swallowed and injure the anus or rectum in their passage from the body. Gunshot wounds and fragments of bone in fractures of the pelvis may involve the rectum or the anus secondarily. Incised wounds, except those made intentionally by the surgeon in operations upon these parts, or accidentally in the operation of lithotomy, are rarely seen, while lacerated wounds occurring during parturition are not uncommon. Injuries of the rectum caused by foreign bodies thrust through the anus, such as a piece of wood, a prong of a hayfork, a tooth of a rake, or the nozzle of an enema syringe, may produce extensive laceration and perforation of the rectum, and even open the peritoneal cavity and wound the intestines. These injuries are always most serious, and are apt to result in septic cellulitis of the pelvic connective tissue or in septic peritonitis, either of which conditions is likely to be followed by a fatal result. When the rectum is injured by a hard or sharp substance which has been swallowed, a localized ulceration of the rectum may result, or, if perforation has occurred, abscess and fistula may follow. Wounds of the rectum resulting from gunshot injuries, as well as those occurring from the fragments in fracture of the pelvic bones, are grave injuries, and are liable to be followed by septic cellulitis or peritonitis, or by the development of abscess and fistula.

Prognosis.—In wounds of the rectum the prognosis depends largely upon the thoroughness of the drainage. In incised wounds made intentionally by the surgeon in which the drainage is free the prognosis is favorable; in extensive lacerated wounds in which the rectum, anus, and surrounding skin are torn, as free drainage is established a favorable termination is not unusual; while punctured rectal wounds, in which there is poor drainage, are very unfavorable, as they are apt to be followed by extravasation of feces, cellulitis, abscess, and grave septic complications.

Treatment.—The wound and the surrounding parts having been thoroughly sterilized, the wound should be closed first by a layer of deep sutures of silk or catgut, and later by superficial sutures, care being taken to bring together the ends of the divided sphincter muscle. If it is found that the surfaces cannot be accurately brought together, a drainage-tube should be introduced before applying the sutures. The same treatment is

applicable to lacerations of the anus and the rectum occurring as a result of parturition. Accidental wounds of the rectum received during the operation of lithotomy usually heal promptly, but, as the rectal wound in these cases is low down, it is generally possible to bring together the edges by a few sutures introduced through the perineal wound.

The treatment of punctured wounds of the rectum, with or without wound of the anus, consists in providing drainage by dividing the sphincter muscle, if not already divided, and the wall of the rectum, as far as the seat of injury, and, after controlling the bleeding, loosely packing the wound with a strip of iodoform gauze. Free drainage being thus established, the wound is allowed to heal by granulation: if after healing it is found that the sphincter action has been lost, a plastic operation should be undertaken to repair the divided muscle.

To prevent infection after wounds or operations upon the rectum, they should be freely irrigated with antiseptic solutions and dressed with iodoform gauze and a pad of bichloride gauze and cotton held in place by a T-bandage. When the puncture of the rectum is complicated by a wound of the peritoneum or intestines and signs of septic peritonitis are present, the abdomen should be opened and the peritoneal or intestinal wound closed with sutures, and, after flushing the abdominal cavity with warm sterilized water, a drainage-tube should be introduced and the abdominal wound closed.

Burns and scalds of the anus and rectum are rare, but occasionally occur. If severe and not immediately fatal, they are apt to be followed by marked contraction, giving rise to stricture, which will necessitate a subsequent plastic operation or colostomy. Their treatment is similar to that of burns and scalds of other parts of the body.

Foreign Bodies in the Rectum.—Foreign bodies may reach the rectum by being introduced through the anus or by entering the rectum from the colon. A great variety of substances has been found in the rectum, such as nails, pins, hair-pins, stones, glass, bottles, and sticks, as well as fecal concretions. We recently removed a hard, smooth, fecal concretion, the size and shape of a hen's egg, from the rectum of a patient, where it had caused her more or less discomfort for a year. Foreign bodies which have been swallowed may lodge in the rectum and have concretions formed upon them, or the foreign body may be introduced accidentally through the anus; hysterical subjects and those suffering from perverted sexual impulse are apt to introduce foreign bodies into the rectum.

Symptoms.—If the foreign body be a small and smooth one, the symptoms caused by its presence may not be marked, consisting principally of a sense of rectal fulness and tenesmus; if a large body be present, more or less obstruction may exist to the passage of feces, and in most cases the presence of the foreign body soon sets up a teasing diarrhœa. If the body be an irregular or hard one, its presence sooner or later causes inflammation and ulceration of the rectal walls, followed by the passage of blood-stained feces and mucus with the stools, and perforation of the rectal wall with the formation of abscess and fistula may subsequently occur.

Treatment.—As soon as the presence of a foreign body is recognized, its removal should be promptly undertaken. It is well before attempting to remove a foreign body from the rectum to administer an anæsthetic, so that the resistance of the sphincter muscle and the movements of the patient may be eliminated. The removal of the body is usually best accomplished by introducing a bivalve or four-bladed rectal speculum, and after thoroughly dilating the blades so as to expose the body, grasping it with the forceps and gently withdrawing it. When the foreign body has caused ulceration, the greatest gentleness should be practised in the manipulations, to avoid perforation of the thinned rectal wall. In some cases it may be necessary to divide the body with forceps before it can be removed; in other cases a scoop or a wire loop may be employed. If ulceration of the rectum has occurred, the cavity should be irrigated with boric acid solution, and the ulcerated portion touched with a ten-grain solution of nitrate of silver. The same application should be made subsequently until the ulcers have healed.

Congenital Malformations of the Anus and the Rectum.—These malformations are comparatively rare; it has been computed that one child in ten thousand is born with a congenital defect of these parts, resulting from arrested development in early fœtal life. The central portion of the alimentary canal is formed from the hypoblast, and is known as the *mesenteron*, consisting of a simple tube terminating at the anterior extremity of the embryo in a blind pouch, and in a pouch at the posterior extremity, which communicates by a minute opening with the neural canal, known as the *neurenteric canal*. An invagination of the epiblast at the posterior extremity of the embryo, known as the *proctodæum*, which forms the anus and the genito-urinary orifices, communicates with the mesenteron about the end of the fifth week. The lower portion of the primitive intestine terminates at first in a cloaca, common to it and the genito-urinary organs, but by the end of the tenth week the anus is separated from the genito-urinary organs by the development of the perineal septum. The failure of development of the perineal septum explains the frequency of the connection between the intestinal tube and the genito-urinary tract in case of imperforate rectum and anus. The various malformations of the rectum and the anus depend upon imperfect development of the proctodæum, incomplete formation of the perineal septum, and persistence of the post-anal gut or neurenteric canal.

Varieties of Malformation.—**1. Congenital narrowing of the rectum and anus, without complete occlusion.** This malformation, if not sufficient to produce marked symptoms of obstruction, may at first escape notice, as the semi-fluid feces of the infant pass readily through the narrow orifice, but as the child becomes older and the feces are more consistent accumulation takes place in the rectum, causing obstruction, and an examination will demonstrate its cause. It is possible also that in many cases where the stenosis is not marked the passage of feces brings about the necessary amount of dilatation. **Treatment.**—This consists in gradual dilatation of the anus and the rectum, and is usually followed by a satisfactory result. It is conducted by passing daily a graduated bougie, or the

oiled finger of the mother or the nurse, which is by far the best and safest of all bougies for this purpose.

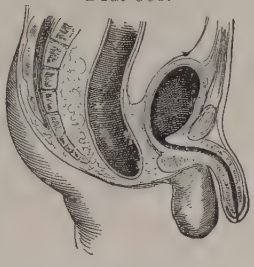
2. **The anus is absent, and the rectum terminates in a blind pouch.** The rectum may not be developed, or may be developed to so slight an extent that it terminates in the abdomen or high up in the pelvis (Fig. 799), or it may be well developed and terminate near the perineum. (Fig. 800.)

3. **The anus may be well formed, as well as the rectum,** but they do not communicate, a membranous diaphragm or fibrous cord existing between them. (Fig. 801.)

Fig. 799.

Rectum terminating in the abdomen. (After Mollière.)

Fig. 800.



Rectum terminating low down near the perineum.

Fig. 801.

Anus separated from the rectum by a membranous diaphragm. (After Mollière.)

4. **The anus is absent, and the rectum terminates in the vagina, usually at its lower portion.** (Fig. 802.) This is the most common variety, representing about forty per cent. of all these malformations. Where there has been failure in the development of the perineal septum, the anus is usually absent and the rectum terminates in some portion of the genito-urinary tract.

5. **The anus is absent, and the rectum terminates in a narrow sinus, which opens beneath the prepuce.** (Fig. 803.) In this variety

Fig. 802.

The anus is absent, and the rectum terminates in the vagina.

Fig. 803.

Rectum terminating at the prepuce. (After Mollière.)

Fig. 804.

Rectum terminating in the bladder. (After Mollière.)

of malformation the rectum may terminate in a fistula, which opens on the perineum.

6. **The anus is absent, and the rectum terminates in the urethra or the bladder.** (Fig. 804.)

7. **The anus is present, but does not communicate with the rectum, which terminates in a blind pouch, while the anus terminates in the vagina.**

8. **Persistence of the neurenteric canal or post-anal gut.** This condition is rarely met with. The anus may be absent and the rectum may open through an aperture in the sacrum, or failure of obliteration of the post-anal gut may result in a diverticulum of the rectum.

Symptoms.—The symptoms presented in malformations of the rectum and anus vary with the variety of malformation. When the rectum terminates in a blind pouch the feces cannot escape, and symptoms of obstruction soon develop, such as vomiting and swelling of the abdomen. In cases in which the rectum terminates in the vagina, feces usually escape freely, and no marked symptoms are present. When, however, the rectum terminates in the bladder or the urethra, or at the prepuce, the escape of feces is usually not sufficiently free, and obstructive symptoms soon develop. In cases in which the anus is absent the condition is usually recognized early, but when the anus is present it is likely to be overlooked until the fact that no feces have been passed has been noticed. Absence of a fecal discharge within a reasonable time after birth should lead to an examination of the rectum, which will reveal the cause. Care should be taken not to give purgatives in these cases before making an examination.

Treatment.—Where the rectum ends in a blind pouch, symptoms of obstruction are soon developed, which if not relieved by immediate operation rapidly prove fatal. In such cases a perineal opening should be made at the usual site of the anus, and if the rectal pouch is low down it should be opened and the edges of the rectum brought down and sutured to the skin. If, however, the rectal pouch is high up in the pelvis, it may be difficult to reach it, but an attempt should be made to do so; excision of the coccyx gives the operator more room and thus facilitates the exposure of the gut. When the rectal pouch is exposed and opened high up, it is not possible to suture the gut to the edges of the wound, and in these cases a good-sized rubber tube should be secured in the wound for a few days. When the pelvis is poorly developed and narrow, the rectum usually ends high up, and it is not likely that it can be reached from a perineal wound.

Where it is found impossible to reach the gut from the perineal wound, this should be closed, and the descending colon should be opened in the left iliac region. Where the anus is present and is separated from the rectal pouch by a membranous or fibrous septum, this should be carefully opened by a crucial incision, and should subsequently be dilated by a bougie or the finger. In cases in which the gut opens into the vagina, if the fecal discharge is free no operation need be undertaken for some time; it is better in these cases to wait until the child is several years of age, when an incision should be made in the region of the anus, the gut exposed and dissected loose from the vagina, and the vaginal opening transplanted and sutured to the anal wound, the vaginal wound being closed with sutures.

Where the rectum ends in the bladder or the urethra, an artificial anus should be established in the left iliac region by iliac colostomy, and if the

patient survives, when he has attained some size an operation may be undertaken to close the communication with the bladder or the urethra. Except in cases of a membranous septum between the anus and the rectum, or in those in which the rectum terminates low down in the pelvis and where it opens into the vagina, the results of operation are not usually satisfactory. A large number of these patients die soon after the operation, but occasionally after a colostomy it has been possible later to expose the bowel and secure it at the site of the anus and subsequently close the artificial anus.

DISEASES OF THE ANUS AND THE RECTUM.

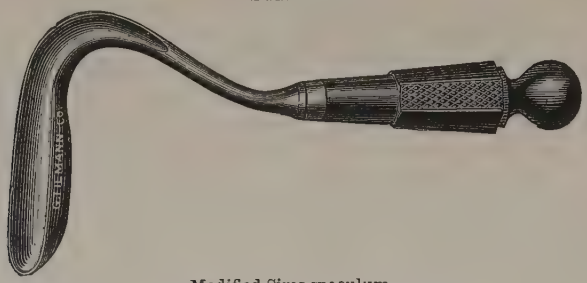
Examination of the Anus and the Rectum.—Before undertaking the treatment of any case of disease of the rectum or the anus, the surgeon should make a careful physical examination of the parts. This is most important from the fact that the majority of patients present themselves for treatment with a diagnosis of piles or fistula; we can call to mind a number of patients who have come under our care who stated that they were suffering from or had been treated for hemorrhoids, in whom an examination revealed ischio-rectal abscess, fistula, fissure, or carcinoma, and in whom valuable time had often been lost by the lack of a careful examination.

In making an examination of the anus or the rectum, the patient should be placed upon the side in the Sims position, or upon the back, with the limbs drawn up and held aside as in the lithotomy position. If possible, an enema should be given before the examination, to empty the rectum of fecal matter. The anus should first be inspected, and the presence of external hemorrhoids, protruding polypus, or a fissure, the openings of fistulæ, the swelling of an ischio-rectal abscess at the anal region, or the presence of eczema of the anus, can usually be made out without difficulty. The patient should be asked to strain slightly, and at the same time the folds of mucous membrane should be separated, so that the presence of a fissure can be observed. In examination of the rectum the finger should be covered with cosmoline, after filling the nail with soap, and introduced into the rectum with a boring motion, and as it is introduced the condition of the sphincter muscle is noted. By the finger from three to four inches of the rectum can be explored, and the presence of a polypus, the internal opening of a fistula, a stricture, or a malignant growth can be made out. Internal hemorrhoids, unless they are well developed, cannot well be felt with the finger. The use of a rectal speculum will enable the surgeon to expose the rectal walls for inspection. This instrument cannot, as a rule, be used with satisfaction unless the patient is under the influence of an anæsthetic. The rectal specula which we have found most satisfactory are the modified Sims speculum (Fig. 805) and the bivalve speculum. (Fig. 806.)

Kelly practises a method of examining the rectum which consists in the use of cylindrical specula from five to fourteen inches in length fitted with obturators. The patient is placed in the knee-elbow position, and as soon as the obturator is removed the rectum becomes distended with air. A head-mirror or an electric lamp is used to illuminate the cavity. By the long

speculum it is possible to obtain a view of the sigmoid flexure. These instruments are most satisfactorily employed under general anæsthesia.

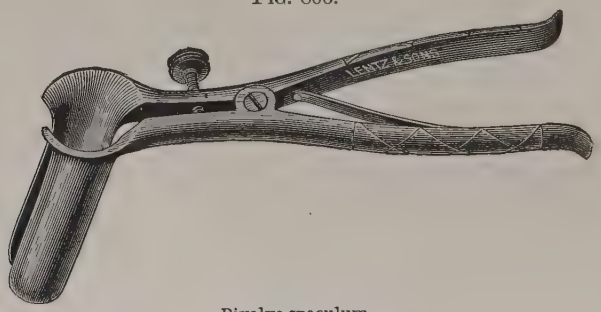
Fig. 805.



Modified Sims speculum.

Examination with a speculum is not required in many cases if a careful examination is made with the finger; and in the case of fistula, the use of a flexible silver probe will show the course and termination of the fistulous

Fig. 806.



Bivalve speculum.

tracts. Examination of the rectum by the introduction of the whole hand can be made if the hand be a moderately small one, but this procedure is to be recommended only in exceptional cases, as it is not unattended with danger, and has been followed by rupture of the rectal wall and fatal peritonitis.

DISEASES OF THE ANUS.

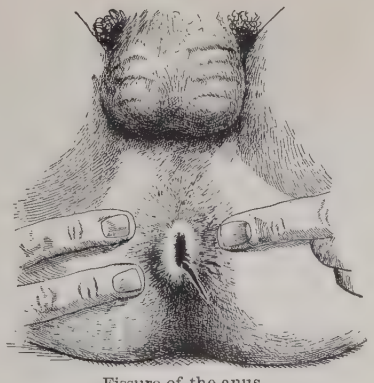
Pruritus Ani.—This affection, which consists in a painful itching condition of the anus, is attended with certain changes in the appearance of the parts. The skin becomes thickened and presents a parchment-like or eczematous appearance, with the exudation of moisture, and is usually covered with scratch-marks. This disease may result from the presence of internal hemorrhoids or of a small fistula, from eczema, from the presence of oxyuris vermicularis, or seat-worms, in the rectum, from pediculi, or from a vegetable parasite, in which case the disease is known as *eczema marginatum*. In other cases no cause can be found for the itching, the affection being due to constitutional conditions, such as gout, or to neuroses of the rectum. **Symptoms.**—The principal symptom is a painful itching, which is usually much aggravated at night, so that it interferes with sleep, the tendency being to scratch the part constantly, which aggravates the

trouble. **Treatment.**—The treatment consists in removing the cause, if it can be discovered. If internal hemorrhoids or a fistula causes the affection, the cure of this condition by an operation should be undertaken. In cases in which the affection arises from seat worms, an enema of carbolic acid, ʒss; glycerine, ℥i; water, fℨviii; or of infusion of quassia, ℥i to Oij, will relieve the trouble. When arising from pediculi the application of tincture of larkspur or of fishberries will destroy the parasites. When the affection is due to eczema marginatum, the use of a weak solution of sulphurous acid or hyposulphite of sodium, followed by an ointment of oleate of bismuth, will act well. In cases of eczema, the use of hot water and green soap and an ointment of oxide of zinc, or of chloroform fʒi to simple ointment ℨi, or of dilute citrine or tar ointment, often is followed by good results. Where no distinct cause can be found, the diet should be regulated, meat being diminished and stimulants and tobacco avoided or used very sparingly; the free use of lithia water is often followed by benefit.

Abscess of the Anus.—This affection, sometimes known as *marginal abscess*, arises from suppuration in an external hemorrhoid, in the mucous follicles of the anus, or in a small fissure of the anus, giving rise to more or less pain in the part: when it arises from an external hemorrhoid a superficial fistula may result, but it usually is attended with no serious consequences. It is not uncommon in children. **Treatment.**—This consists in making a free opening with a bistoury, in doing which the tip of the index finger should be passed into the rectum to steady the abscess and make it more prominent before it is incised. After opening the abscess, a narrow strip of gauze should be introduced into the cavity and a gauze dressing applied. The wound usually heals in a few days.

Fissure or Irritable Ulcer of the Anus.—This consists of a small linear ulcer of the mucous membrane, which is usually situated at or near the posterior commissure, but may occur at any other part of the anus, and may arise from a slight traumatism, or from a rent in the mucous membrane caused by the passage of hard feces, or from a broken-down herpetic vesicle. (Fig. 807.) Ball considers that this ulcer results from an injury of one of the anal valves by some irregularity in the fecal mass which separates its lateral attachments, and that the ulcer thus formed is reopened at each movement of the bowels, so that it cannot heal, the conditions presented being very similar to those in hang-nail. The peculiar symptoms presented by this ulcer seem to depend not upon its special cause, but upon the fact that the ulcer is within the grasp of the sphincter muscle, and, being subjected to constant motion, cannot heal.

Fig. 807.



Fissure of the anus.

Fissure of the anus is usually observed in adults, but occurs also in children. We have seen several cases of fissure of the anus with well-marked symptoms in this class of patients, and Jacobi thinks that fissure of the anus

in children is a much more common affection than is generally supposed. The frequency of seat-worms in children, causing them to scratch and injure the mucous membrane of the anus, may be a factor in the production of fissure.

Symptoms.—The most characteristic symptom is intense paroxysmal pain, which comes on immediately or a short time after a movement of the bowels. The pain may be so severe that it completely incapacitates the patient for work or exercise, and he is compelled to rest until it has passed away. When it has once subsided it does not appear until the bowels are again moved. The patient is apt to postpone going to stool for a number of days, and when the bowels move the affection is aggravated by the passage of large and hard fecal masses. Occasionally a few drops of blood from the ulcer escape with the feces. During the paroxysm of pain reflected pains may be felt in the neck of the bladder, in the loins, and in the thighs. The pain may last for only a few minutes or may persist for hours.

Treatment.—The results of treatment are usually most satisfactory, and consist in local applications to the ulcer, or in partial division or stretching of the sphincter, which causes a temporary paralysis of the muscle and puts the ulcer at rest until repair can take place. We were formerly of the opinion that only the radical method of treatment was followed by success, but recently we have seen cases in which recovery followed where less heroic methods were employed. In some cases the daily application to the ulcer of a ten- to fifteen-grain solution of nitrate of silver, and an ointment of iodoform, or of calomel, gr. x, with the use of laxatives to produce a daily soft motion, will be followed by a cure. The application of pure carbolic acid to the fissure may also be followed by good results. This treatment is, we think, especially adapted to fissure of the anus in children, although we have seen it followed by good results in adults. A method, however, which is more certain consists in having the bowels moved by a laxative or an injection, and after administering an anæsthetic the anus is irrigated with a solution of boric acid; the base of the ulcer is then incised with a sharp bistoury, partially dividing the sphincter, the thumbs are introduced into the rectum, and the sphincter is well stretched. (Fig. 808.)

Fig. 808.

Stretching the sphincter.

Stretching of the sphincter without incision of the ulcer may also be practised, and by so doing the muscular fibres are stretched or lacerated, so that paralysis of the muscle results. After the sphincter has been divided or stretched, an opium suppository is introduced into the rectum, and a small gauze dressing is applied to the anus. The bowels should be kept quiet for about three days, and after this time daily movements are

secured by laxatives. The first movement is generally painless, and at the end of a few days the ulcer is usually healed. Ball, after administering an anæsthetic, dilates the anus and makes a V-shaped incision, removing the torn-down anal valve.

Vegetations or Warts of the Anus.—These are papillary overgrowths, similar in structure to warts observed in other parts of the body, and are covered with squamous epithelium. They occur in both adults and children, and often attain great size. From their situation they are compressed between the nates, become moist, and are accompanied with a certain amount of offensive discharge. **Treatment.**—If the parts can be kept dry, the growths shrink and may disappear. In growths of moderate size, dusting them with a powder composed of oxide of zinc and lycopodium, equal parts, will often be followed by their rapid disappearance. The daily application of an ointment of salicylic acid, ʒss, lanolin, ℥i, will also cause their removal. When the growths are large, the application of the solid stick of nitrate of silver, or of a saturated solution of chromic acid, may be employed with advantage, or they may be removed with a knife, curette, or scissors, or by the use of the actual cautery. The only objection to their removal by the former means is the hemorrhage which follows: this, however, can easily be controlled by the use of a compress or by the cautery.

Syphilitic Affections of the Anus.—These consist in the presence of mucous patches, moist papules, and condylomata, which occur both in acquired and in inherited syphilis. Allingham has called attention to the presence of numerous tracks or fissures in the mucous membrane of the anus in children suffering from hereditary syphilis. Condylomatous growths appear frequently upon previously existing papules or mucous patches, and are accompanied by a very fetid discharge. These growths are to be distinguished from the simple form of vegetations which is observed in the anal region. **Treatment.**—The treatment of syphilitic lesions of the anus should be both constitutional and local. The constitutional treatment consists in the administration of mercury or of iodide of potassium, or of both combined. The local treatment consists in touching them with acid nitrate of mercury, or in dusting them with a powder composed of equal parts of calomel and oxide of zinc. Under these methods of treatment they usually disappear rapidly.

Epithelioma of the Anus.—This affection may have its origin in the mucous membrane or in the skin of the anus, or these structures may be involved by an extension of the disease from the rectum. Primary epithelioma of the anus is of the squamous type, and is comparatively rare. Epithelioma of the anus is often confounded with hemorrhoids, which mistake should not occur if a careful examination of the part is made. **Treatment.**—If the disease is confined to the mucous membrane and skin of the anus, the diseased tissue should be freely excised and the mucous membrane brought down and sutured to the edges of the skin. In cases in which the anus is involved in the growth by extension of a similar growth from the rectum, no local operation can be employed with advantage, but, if the rectum is not too extensively involved, excision of the rectal growth with the anal growth should be practised.

Stricture of the Anus.—This condition may be congenital, or may result from wounds, burns, scalds, or malignant growths of the anus, and occasionally results from operations upon the rectum, in which free removal of the structures has been practised. Sloughing of the tissues after the injection treatment for hemorrhoids and subsequent contraction have not infrequently resulted in a marked stricture of the anus. We had recently under our care a man who had suffered from a stricture of the anus, through which the point of a No. 21 bougie could be passed only with difficulty. The stricture in this case resulted from sloughing following the injection of hemorrhoids by an irregular rectal specialist. **Diagnosis.**—The patient usually suffers from gradually increasing difficulty in passing formed motions, and notices that the stool when passed is tape-like in appearance. Examination shows that the anal orifice is contracted, and in severe cases the finger cannot be passed through the stricture. **Treatment.**—The treatment of congenital strictures of the anus has been described. When the stricture results from malignant disease of the anus, the growth should be excised if possible. If the stricture is due to cicatricial contraction following injuries or operations, gradual dilatation should first be employed, and this may be done with the finger or with graduated rubber bougies. If this method of treatment is not followed by good results, the cicatricial tissue should be excised and the mucous membrane brought down and sutured to the edges of the skin.

Diphtheria of the Anus.—This condition is occasionally seen in patients suffering from diphtheritic deposits in the throat and nose. The affection is not often observed, and usually occurs as a late manifestation of the disease. In such cases the deposit of diphtheritic membrane appears upon the mucous membrane of the anus, and may extend to the buttocks or the vulva. The prognosis in this affection is extremely unfavorable. The few cases that have come under our notice have all terminated fatally. **Treatment.**—The treatment consists in the use of such constitutional remedies as are of service in the treatment of diphtheria, the injection of antitoxine and the free use of stimulants. The local treatment consists in the application of a solution of bichloride of mercury 1 to 2000.

Fistula in ano is considered in connection with ischio-rectal abscess.

DISEASES OF THE RECTUM.

Proctitis.—Proctitis, or inflammation of the rectum, may be traumatic, catarrhal, dysenteric, or gonorrhœal.

Traumatic proctitis may result from injury to the walls of the rectum received from without, from foreign bodies lodged in the rectum, from the careless use of an enema syringe, or from injury to the mucous membrane by hardened feces or materials contained in the feces. **Acute catarrhal proctitis** may result from the irritation produced by the impaction of masses of hardened feces in the rectal pouch, from the use of drastic purgatives, or from prolonged sitting upon a cold or wet seat, and in children may follow the irritation produced by seat-worms. This affection may also develop in connection with internal hemorrhoids, prolapsus, stricture, or tumor of the rectum. In acute proctitis the mucous membrane alone is

involved, and is congested and hyperæmic. **Symptoms.**—The symptoms are pain and tenderness, and the frequent passage of feces mixed with mucus and blood; œdema and often slight prolapse of the mucous membrane of the anus are also observed. The patient at the same time complains of a sense of heat and weight about the pelvis, and often suffers from vesical irritation.

Chronic Catarrhal Proctitis.—This affection generally follows acute proctitis, but may result from the presence of growths in the rectum, or from pressure upon the rectal wall caused by uterine displacements. In this form of the disease the mucous membrane is thickened and indurated, and ulceration of the surface at various points is usually present. **Symptoms.**—These are those of acute proctitis in a modified degree. Pain and tenesmus are not prominent symptoms, and constipation is apt to be present. The patient often complains of a sense of fulness or weight in the rectum; the discharge of blood is not excessive, and mucus and purulent matter escape from the rectum when a movement occurs.

Treatment.—This in the *acute* form consists in putting the patient at rest in bed, and in the administration of purgatives to empty the lower bowel. The saline purgatives, such as sulphate of magnesium or Rochelle salt, act well, but castor oil or compound liquorice powder may be used with equally good results. If pain and tenesmus continue after the rectum has been emptied, an injection of thirty minims of laudanum to an ounce of starch water should be thrown into the rectum, or a suppository containing extract. opii, gr. ½, ol. theobrom., gr. xxx, if its introduction does not give the patient pain, can often be used with advantage. The diet should also be restricted to meat broths, milk, and eggs.

In the *chronic* form of the affection the same treatment as regards rest in bed, emptying the rectum, and restriction of the diet should be employed, and in addition the rectum should be carefully irrigated with warm sterilized water by means of a tube, and an enema of nitrate of silver solution, five grains to two ounces of water, should be injected and allowed to remain for a few minutes, the rectum afterwards being washed out with warm water. This injection should be used daily or on alternate days, and in addition suppositories of extract of opium, belladonna, and iodoform may often be employed with advantage.

Dysenteric Proctitis.—This may exist as an acute or as a chronic affection. In its acute form it is not apt to come under the care of the surgeon, but the chronic form of the disease gives rise to ulceration or stricture of the rectum, which condition sooner or later demands surgical treatment.

Gonorrhœal Proctitis.—If gonorrhœal discharge is brought in contact with the mucous membrane of the rectum, there is rapidly set up an acute purulent inflammation, the mucous membrane becoming congested and red or purple in appearance, and a profuse purulent or muco-purulent discharge occurs, infection in most cases occurring from the gonorrhœal discharge running backward and reaching the anus and from this point finding its way into the rectum. Infection in this manner is more apt to occur in women than in men. Infection may also occur from the discharge being brought directly in contact with the mucous membrane of the rectum by

unnatural intercourse. **Symptoms.**—The prominent symptoms are pain, tenesmus, and a profuse muco-purulent or purulent discharge. A microscopic examination of the discharge will generally reveal the presence of gonococci. **Treatment.**—This consists first in irrigation of the rectum with warm water, and next in the introduction of astringent solutions, as a solution of sulphate of zinc, gr. v, water, ℥i, or one of nitrate of silver, gr. ½, water, ℥i. After either of these solutions has remained for a few minutes, it should be allowed to escape and the rectum irrigated with warm water. The injections should be increased in strength if they do not cause pain, and administered until the discharge ceases and the other symptoms of the disease disappear.

Periproctitis.—This is an inflammation of the tissues surrounding the rectum, and is due to septic infection. It may follow accidental wounds of the rectum or of the surrounding tissues, or may result from surgical operations upon the anus or the rectum, and may exist as a localized or a diffused septic process. **Localized Periproctitis, or Rectal Abscess.**—Inflammation of the perirectal tissues may give rise to abscess, which may involve the superficial tissues in the region of the anus, the walls of the rectum, or the ischio-rectal fossa. **Treatment.**—This consists in an incision into the inflamed tissues to evacuate the pus, and the introduction of a gauze drain to secure free drainage.

Diffused Periproctitis.—This is a septic inflammation of the perirectal connective tissue which follows traumatisms and operation upon the rectum, and is characterized by high temperature, rigors, sweating, vomiting, pelvic pain, and abdominal distention. The infective process involves the connective tissue of the ischio-rectal fossa, and extends by the lymph-paths to the pelvis, and if not arrested by treatment is apt to terminate in septic peritonitis and death. The difficulty of obtaining and maintaining asepsis in wounds of this region is fully recognized, and the surgeon, therefore, should be very careful as regards asepsis in all wounds or operations upon the rectum. Free drainage is one of the most important means that can be employed in these cases to prevent septic infection. **Treatment.**—In cases of diffused periproctitis, as soon as the condition is recognized free incision should be made to expose the infected tissues and secure free drainage, the parts thoroughly irrigated with a bichloride solution, and rubber or gauze drains introduced. The patient should be given stimulants, such as strychnine, alcohol, and digitalis, and if peritonitis has not developed recovery may take place.

Gangrenous Periproctitis.—This affection, which consists in an intense septic infection of the perirectal cellular tissues, is occasionally seen following wounds of the rectum, although in the cases reported by Jordan no history of an injury could be discovered, but it occurred in persons who were heavy eaters and drinkers. This disease presents many symptoms in common with traumatic spreading gangrene, and probably arises from the same microbic infection. **Symptoms.**—The skin in the region of the anus and buttocks becomes brawny and hard, and upon deep pressure crepitation can be felt, the temperature is elevated, the pulse is rapid, and death usually results from extension of the gangrenous process into the pelvis or from ex-

haustion. We had under our care recently a case of gangrenous periproctitis in a lady forty years of age, who about thirty-six hours before we saw her had her sphincter stretched for the relief of hemorrhoids by an irregular rectal specialist. Inspection of the anal region showed a brawny swelling of the skin, extending to the buttocks on both sides of the anus, and upon deep pressure crepitation could be distinctly felt in the subcutaneous tissues. The patient was etherized, and a curved incision several inches in length was made on each side of the anus through the indurated tissues outside of the edge of the sphincter, exposing the cellular tissue, which was found to be of a leaden color and gangrenous. The wound was thoroughly irrigated, and two large rubber drainage-tubes were introduced to a depth of four inches, as well as some strips of iodoform gauze, to secure free drainage. After the incisions were made, the local and constitutional condition of the patient soon improved, and, although sloughs were discharged from the wounds for several weeks, she made a good recovery. **Treatment.**—The treatment of this condition consists in early and free incisions to secure good drainage, antiseptic irrigation, and the internal use of stimulants and tonics.

Gangrene of the Rectum.—This condition, in which gangrene of more or less of the rectal tube occurs, is an extremely rare one. It is said, however, to be not uncommon in tropical climates. The condition seems to bear no relation to wounds of the rectum, but develops in persons of intemperate habits upon exposure to cold and dampness. The symptoms are those of diffused periproctitis. In a patient fifty years of age recently under our care who presented these symptoms, an incision showed that the lower portion of the rectum was gangrenous although the anus and the surrounding skin were not affected. This patient a few days afterwards passed about three inches of the lowest part of the rectal tube through one of the incisions, and was in a fair way to recovery, when she suffered from an attack of heat exhaustion during a period of intense heat, which ended fatally.

Treatment.—So far as we know, all cases of extensive gangrene of the rectum have terminated fatally. The treatment indicated is free incision of the tissues in relation with the rectum to establish drainage and facilitate the escape of the sloughing bowel, and if recovery should occur an inguinal colostomy would subsequently be required to relieve the obstruction to the passage of feces from the lower end of the rectal tube, by reason of the contraction resulting from the cicatrization of the granulating cavity.

Superficial Rectal Abscess.—This affection is characterized by pain and swelling in the anal region. This variety of abscess is not apt to lead to serious consequences, although if not opened promptly it may give rise to a superficial rectal fistula. **Treatment.**—The treatment consists in making a free incision in the inflamed part, even before the presence of pus can be demonstrated; the wound should be irrigated, and a strip of iodoform gauze should be loosely packed into it to prevent adhesion of the edges of the wound. Under this treatment prompt healing usually occurs in a few days.

Ischio-Rectal Abscess.—This may be acute or chronic. The latter form of abscess often results from tuberculous infection, and is apt sooner or

later to become infected with pyogenic organisms and present the symptoms of the acute affection. Ischio-rectal abscess may result from traumatisms of the perirectal tissues produced by kicks, blows, or falls, giving rise to acute phlebitis, from infection of wounds of the mucous surface of the rectum resulting from operations or injuries, from materials contained in the feces, such as fish-bones, sharp portions of shell-fish, pieces of bone, or any other hard substance. It may also occur as the result of ulceration of the rectum, or from rupture or perforation of the rectal wall in connection with stricture or cancer of the rectum.

Symptoms.—The development of ischio-rectal abscess is usually attended with fever, and a well-marked rigor or chill often occurs. Pain of a dull, throbbing character is a prominent symptom, and is very much increased by the act of defecation. A symptom upon which we lay great stress, and which is not generally described, is pain in the rectum upon coughing. This we have found an early and constant symptom, and one which is present when the pus is deeply seated and many of the other symptoms are wanting. Irritability of the bladder or retention of urine may also be present. The abscess is usually situated upon the lateral aspect of the anus, and may present a prominent fluctuating swelling, or the swelling may be scarcely marked, and the situation of the abscess be recognizable only by a localized brawny and thickened condition of the skin, with some œdema. Examination of the rectum with the finger will sometimes reveal bulging of the rectal wall in the region of the abscess.

Ischio-rectal abscess, if left to itself, opens into the rectum, and a second opening is apt to occur on the cutaneous surface near the anus; or it may open first upon the skin, and subsequently an opening occurs into the rectum, and there results a persistent sinus, which is known as a *fistula in ano*, or *rectal sinus*.

Treatment.—In no abscess is the indication for early and free incision more urgent, for an opening relieves the patient's pain and renders extremely favorable the prospect of repair without the formation of a fistula. The treatment of this condition, therefore, consists in early and free incision; the surgeon should not wait until the presence of pus is evident, but should make an incision if deep induration of the tissues in the anal region can be felt on palpation.

The patient should be anæsthetized and the region of the anus and buttocks thoroughly sterilized, and it is well to have him placed upon his back with the pelvis resting upon the edge of the table—that is, in the lithotomy position. A curved incision, several inches in length, is made over the swelling or indurated tissue outside of the edge of the sphincter muscle, and the tissues are carefully divided until the pus-cavity is reached, care being taken that the dissection does not go too close to the wall of the rectum. When the abscess-cavity is reached, this should be incised to its full extent, the finger introduced to break down any bands or pockets, and the cavity gently curetted. To expose the cavity fully, one or more incisions at right angles to the first incision, extending out upon the buttock, may be required. As drainage is the most important factor in the treatment, the incisions should be free. The cavity should next be thoroughly

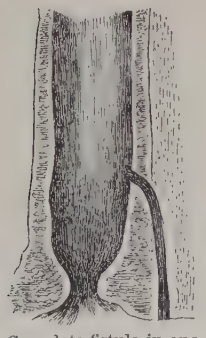
washed out with a bichloride solution, and lightly packed with strips of iodoform gauze, after which a good-sized pad of sterilized or bichloride gauze, and a pad of cotton, should be placed over the wound and held in place by a T-bandage. The opening of these abscesses by a small puncture is apt to result in a permanent sinus, which is likely soon to communicate with the rectum, because of the lack of drainage.

The **after-treatment** consists in introducing a one-grain opium suppository into the rectum and keeping the bowels at rest for three or four days, at which time a laxative should be given. The dressing is usually changed upon the third day: the packing is gently removed, the wound is irrigated, and a few strips of iodoform gauze are loosely packed into it; and this method of dressing should be continued until the wound has healed from the bottom by granulation. In deep and extensive abscesses it is often some weeks before the wound is solidly healed, but, as a rule, if they are treated in this manner the results as regards healing without the formation of a rectal fistula are good.

Fistula in Ano, or Rectal Sinus.—This consists in a sinus resulting from an ischio-rectal abscess which communicates with the cavity of the rectum or is in close relation with its wall.

A complete fistula is one in which a communication exists between the rectum and the cutaneous surface by means of a sinus. (Fig. 809.) **A blind internal fistula** consists of a suppurating tract communicating

Fig. 809.

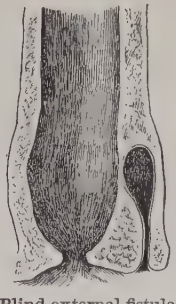


Complete fistula in ano.

Fig. 810.

Blind internal fistula.

Fig. 811.



Blind external fistula.

with the rectum, but having no external opening upon the skin. (Fig. 810.) **A blind external fistula** consists of a suppurating tract in close relation with the wall of the rectum, having an opening upon the cutaneous surface in the region of the anus. (Fig. 811.) A form of rectal fistula is also occasionally seen which is known as a **horseshoe fistula**, in which the pus has burrowed around the rectum from its point of origin, and communicates with the cavity of the rectum on opposite sides of the bowel and with the cutaneous surface at one or more points. (Fig. 813.)

Examination of Rectal Fistulæ.—In examining a patient suffering from *fistula*, he should be placed upon his back and a fine silver probe introduced into the external opening, the index finger being passed into the rectum. By gently manipulating the probe, while at the same time the

finger in the rectum is made to follow its direction, if an internal opening is present it may be brought in contact with the finger. A small bunch of granulations can often be felt in the wall of the rectum, indicating the position of the internal opening. The sinus leading to the rectal opening may be very tortuous, or may be branched so that great patience and delicate manipulation will be required before the end of the probe can be made to enter the rectum. If the internal opening is very small, it may be impossible to pass the probe through it and thus locate it. In cases, therefore, where an internal opening is suspected, a little colored fluid may be injected into the sinus, and if an internal opening exists it will be seen to escape from the rectum, when the position of the opening may be located by the use of a rectal speculum.

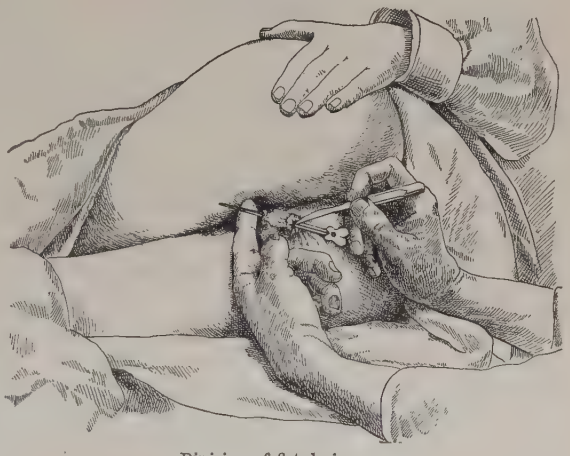
In *blind external fistula* the probe can usually be felt near the wall of the rectum at some point, but cannot be made to enter the cavity of the gut. In examining a patient suffering from blind internal fistula, the finger should be placed in the rectum, when the site of the internal opening can often be felt. Palpation of the skin in the anal region will usually reveal an indurated spot which marks the point where the sinus approaches the skin. A bent probe introduced into the internal opening may be passed into the sinus and can be felt under the skin. In cases of *horseshoe fistula* and very tortuous fistula, a satisfactory examination of the fistulous tracts cannot usually be made without the aid of an anæsthetic. In examining cases of fistula the fact should not be lost sight of that abscess connected with diseases of the spine, sacrum, or hip sometimes opens into the rectum, or the pus reaches the cutaneous surface in the region of the anus by following the rectal fascia. In such cases a careful examination of the patient will usually reveal the source of the disease.

Symptoms.—The symptoms of rectal fistula vary greatly, and depend largely upon the character of the fistula and whether there is active suppuration in the fistulous tract. In complete rectal fistula there may be an escape of feces, if liquid, from the fistula, and also of pus, and the involuntary discharge of flatus. Pain is usually not a prominent symptom if drainage from the fistulous tracts is free, but if they are closed by granulations acute pain may be experienced, followed by a discharge of pus and relief from pain. In blind internal fistula pain and the escape of pus with the stool are more apt to occur than in the other varieties, and in this fistula, as well as in the complete one, a few drops of blood may be noticed upon the feces after they have been passed.

Treatment.—In complete fistula the division of the tissues between the rectal and cutaneous openings is the only operation which is followed by a cure. The parts should be sterilized, and after the patient has been anæsthetized a director should be passed into the external opening and its extremity brought out of the anus. The tissues upon the director should then be divided, care being taken that the division of the sphincter muscle is at a right angle to its fibres (Fig. 812), for such a division is less likely to be followed by incontinence than an oblique division would be. In complicated fistula the fistulous tracts should be laid open a little at a time, and not cut directly through the sphincter ; when thus exposed they should be explored ;

if branching sinuses are present these should be freely opened up by incisions, and after curetting and irrigating them they should be loosely packed with strips of iodoform gauze. If the suppurating tract is a straight one, it may be thoroughly curetted, or the cicatricial tissue may be excised, and, after being irrigated, the deep portions of the wound, as well as the divided sphincter muscle, may be brought together by sutures. This method has recently been employed with success, but we think it should be practised only in selected cases, such as have just been mentioned, and that in the majority of cases the method of packing to secure healing of the wound from the bottom by granulation is the procedure most likely to be followed by a permanent cure. **After-Treatment.**—After packing or closing the wound with sutures, an opium suppository should be introduced into the rectum, and a pad of bichloride gauze and cotton placed over the wound and held in position by a T-bandage. The bowels should be kept quiet for three or four days, and then moved by a laxative. The wound should be dressed at the end of the third day, and after the packing has been removed it should be irrigated and a few strips of iodoform gauze loosely packed in the wound, subsequent dressings being made in the same manner until the wound has healed, which usually requires several weeks.

FIG. 812.



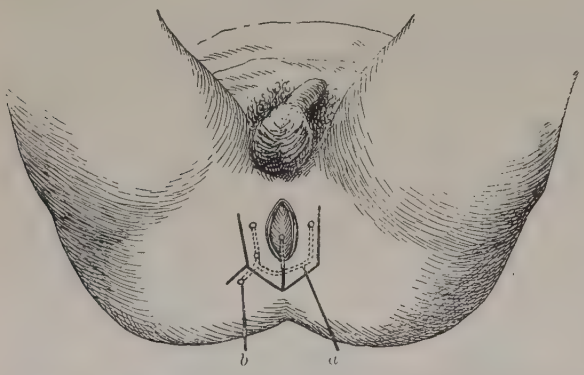
Division of fistula in ano.

A single division of the sphincter is not apt to be followed by incontinence. In cases, however, in which two or more internal openings exist, or in a *horseshoe fistula*, or where there are a number of external openings with a single internal opening, the greatest judgment must be exercised by the surgeon to obtain a satisfactory result as regards healing of the sinuses without the production of incontinence. When a number of sinuses exist with one internal opening, they should be laid open freely, and finally the sphincter and superimposed tissues should be divided. When a horseshoe fistula, with two or more openings into the rectum, exists, the incisions should be so planned that the sinuses shall be opened freely, and the sphincter muscle divided at one point only, corresponding to the opening of one of the sinuses (Fig. 813), for if the sphincter were divided at two points incontinence would be almost certain to follow. After all the sinuses have healed, with the exception of the one leading down to the second rectal opening, this can be divided with little risk of incontinence.

In the treatment of *blind internal fistula* the incomplete fistula should be converted into a complete one by making an external opening at the lowest

point of the sinus; a director should be introduced into the external opening and brought out at the internal opening, and the tissues divided upon the director; the subsequent treatment of the wound is similar to that in the case of complete fistula. In *blind external fistula* the sinus should be freely laid open and curetted, and after being irrigated should be loosely packed with strips of gauze. In this variety of fistula, if the end of the fistula is separated from the rectum by the mucous membrane only, and is low down in the rectum, it is advisable to make the fistula a complete one and divide the tissues and the sphincter.

Fig. 813.



Horseshoe fistula: *a*, fistulous tract; *b*, lines of incision exposing the sinuses and dividing the sphincter.

In patients who refuse operative treatment, or in cases of fistula in which the internal opening is very high up in the rectum, an *elastic ligature* may be introduced through the external and the internal opening and brought out of the anus and firmly tied, and will in a few days cut its way out. The resulting wound should be dressed as in cases of division of the tissues with the knife. This method of treatment is painful, and possesses no advantage over the method of incision with the knife, except that it is accomplished without the loss of blood: it is to be employed only in the cases before mentioned.

Incontinence following single division of the sphincter is rare, but occasionally occurs, and is very apt to follow multiple section of the sphincter. It is not likely to be a troublesome symptom unless the bowels are loose. If incontinence exists, the edges of the sphincter muscle should be exposed by incision and brought together by deep sutures, and the skin approximated by superficial sutures. This condition can also be remedied by the application of the cautery to the skin and mucous membrane over the sphincter, the Paquelin cautery being used and three or four radiating eschars being made, in the healing of which the skin and the mucous membrane become drawn to one side and puckered, so that involuntary escape of feces does not take place.

HEMORRHOIDS, OR PILES.

Hemorrhoids, or piles, which arise from dilatation and increase in the blood-vessels in the lower end of the rectum, are extremely common, and are met with in all conditions of life. Hemorrhoids are most frequently observed in middle life, and are rarely seen in children, being occasionally met with in this class of patients. We have operated upon a boy of five years for internal hemorrhoids.

Various causes have been assigned to account for the frequency of hemorrhoids in man, but the most satisfactory explanation of their etiology is

upon anatomical grounds, the erect posture, and the fact that the veins of the interior of the rectum empty into the superior hemorrhoidal vein, which in turn empties into the portal vein, favoring their development. The veins in leaving the rectum pass obliquely through the muscular coat of the bowel, and are frequently subjected to pressure. They are also without valves, and the blood-current may feel the effect of obstruction in the portal vein.

Pathology.—In all forms of hemorrhoids there are dilatation and increase in the blood-vessels, with more or less proliferation of the connective tissue. A sudden increase in size of hemorrhoidal tumors may result from phlebitis, thrombosis, or perivascular inflammation, which causes a clotting of blood within the previously existing varicose veins. Hartmann and Lieffering consider that phlebitis of the hemorrhoidal veins is due to the presence within the veins of the bacterium coli communis.

Hemorrhoids, for practical purposes, may be classified as external or internal, according as they are below or above the external sphincter muscle. An **external** hemorrhoid generally consists of a dilatation of an external hemorrhoidal vein, is covered by skin, is situated below the external sphincter, and is in connection with the general venous system. An **internal** hemorrhoid, on the other hand, consists of a dilated branch of the middle or internal hemorrhoidal veins, is covered by mucous membrane, is above the external sphincter, and is in connection with the visceral venous system. As the anastomosis between these sets of veins is very free, hemorrhoids are often observed which arise from both sources and are known as **intero-external** hemorrhoids.

External Hemorrhoids.—This variety of hemorrhoids is due to a dilatation of the external hemorrhoidal veins, and exists as a small venous tumor, from the size of a pea to that of a filbert, containing fluid blood, or as a tumor composed of varicose veins with a slight proliferation of their connective tissue, situated at the verge of the anus, or as tags of skin and connective tissue at the verge of the anus. The last-named variety often results from external hemorrhoids which have been inflamed and have undergone either resolution or suppuration.

Symptoms.—External hemorrhoids, as a rule, unless inflamed, cause the patient little discomfort; when, however, thrombosis occurs, or the hemorrhoid becomes inflamed, the pain is severe, and is increased by exercise and by movement of the bowels. Spasmodic contraction of the sphincter and levator ani muscles in this condition is quite common, and adds greatly to the patient's discomfort. If the inflamed hemorrhoid does not suppurate and resolution takes place, the swelling gradually subsides and the pain diminishes. If, however, suppuration occurs in the tumor, after the pus is discharged the pain quickly disappears, and the tumor gradually shrinks up, leaving a tag composed largely of skin and connective tissue. External hemorrhoids composed of skin and connective tissue are apt to give rise to eczema of the anus, and may be accompanied with pruritus, or a small fissure may exist at the base of one of these tags, which causes pain after stool.

Treatment.—The treatment of inflamed external hemorrhoids is either palliative or radical. The palliative treatment consists in rest in the recum-

bent posture, the administration of a saline purgative, and the local use of an ointment of ext. belladonnæ, gr. xv ; ext. opii, gr. x ; ext. hamamelidis, ʒi ; adipis, ℥i. or the application of an ice cap to the inflamed tumor. Under this treatment the pain and swelling subside in two or three days. If the inflammation is not arrested and suppuration occurs in the tumor, hot applications should be used, or, better, the tumor should be incised, to allow the pus to escape, for if this is not done the patient may suffer for several days before a spontaneous evacuation of the pus takes place.

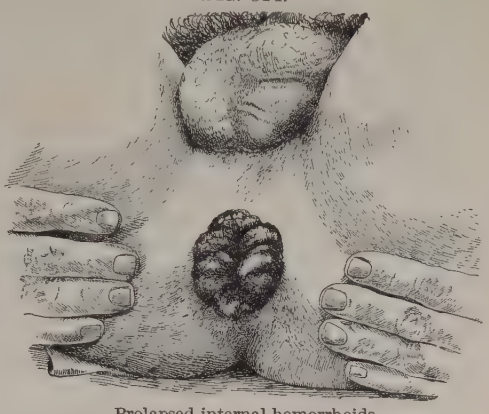
The **radical** treatment consists in incision or excision, and, as the procedure is painful, local anæsthesia by cocaine or ethyl chloride may be employed. **Incision.**—The tumor should be gently washed with soap and water, and finally with bichloride solution, and after it has been fixed with the finger it should be freely split open with a narrow, sharp bistoury, and the contained blood-clot turned out ; little bleeding usually occurs, and after washing the cavity with bichloride solution a small strip of gauze is pressed into the cavity, or it may be dusted with powdered boric acid, and a gauze pad is placed over the wound and held in place by a T-bandage. The pain is quickly relieved by this procedure, and the wound is usually healed in three or four days. **Excision.**—This operation is especially applicable to the cutaneous variety of external hemorrhoids, and, as it is painful, and as a number of individual tumors are often to be removed at the same time, it is well to do the operation under general anæsthesia. The parts being sterilized, each tumor is grasped with forceps and two short skin-flaps are dissected from its base, and the base of the tumor is divided below the line of the flaps. The flaps are next approximated with one or two fine sutures of catgut or silk. The same procedure is repeated until all the tumors have been removed. Bleeding in this operation is usually very slight. The tumor may also be cut off, leaving a short stump close to its attachment to the skin, and the base cauterized with the point of a Paquelin cautery at a dull-red heat. The parts should next be dressed with powdered boric acid, and a gauze pad applied and held in place with a T-bandage.

Internal Hemorrhoids.—These tumors arise from dilatation of the middle and superior hemorrhoidal veins, and occupy a position above the sphincter : they are of two varieties, *capillary* and *venous* hemorrhoids. The **capillary** hemorrhoid is a tumor made up of arteries, veins, and capillaries, usually of moderate size and a bright-red color, with a granular surface, covered by a thin layer of mucous membrane. This variety of hemorrhoid bleeds freely, and is generally found to be present in cases in which free hemorrhage is a prominent symptom. The **venous** hemorrhoid is a tumor composed of freely anastomosing dilated and tortuous veins which contain pouches and are bound together by connective tissue. The tumor is supplied with blood by one or more arteries of considerable size which enter at its base. Venous hemorrhoids are usually much larger than capillary hemorrhoids, but the two varieties may exist in the same case, a small capillary hemorrhoid growing from the surface of a venous hemorrhoid.

Symptoms.—The most marked symptom of internal hemorrhoids is bleeding, which may be profuse in the capillary hemorrhoid, but is also present in venous hemorrhoids after they have existed for some time, may

be so free after each movement of the bowels as to cause the patient to present marked symptoms of anæmia, and is occasionally so profuse as to produce syncope. Prolapse of internal hemorrhoids at stool is common, but the tumors can usually be returned within the sphincter without difficulty. (Fig. 814.) Pain in internal hemorrhoids is not common, unless the tumors become inflamed or strangulated. Strangulation and gangrene may occur if the hemorrhoids are extruded from the anus and are tightly grasped by the sphincter. Mucous discharge from the anus may also be quite free in case of internal hemorrhoids.

Fig. 814.



Prolapsed internal hemorrhoids.

Diagnosis.—Internal hemorrhoids may be confounded with cancer of the rectum, polypus, and prolapsus, as these diseases present, in common with internal hemorrhoids, bleeding and a tumor; but a careful examination cannot fail to disclose the true nature of the trouble. A prolapsed and congested polypus presents some resemblance to internal hemorrhoids, but upon reducing the polypus and introducing the finger its attachment to the rectal wall by a pedicle can easily be felt. The appearance of a case of prolapsus is characteristic, and a malignant growth, with its comparatively firm structure and its surrounding induration, cannot, after careful exploration, be confounded with hemorrhoids.

Treatment.—Operative treatment is not required in all cases of hemorrhoids. Internal hemorrhoids may be symptomatic of other diseases, such as disease of the liver or of the kidneys, or may be due to malignant or benign stricture of the rectum at a higher point, or to the presence of a vesical calculus, stricture of the urethra, or enlarged prostate, and in women pregnancy or uterine disease may be the cause of their development. In such cases the condition which is a factor in their production should be removed by medical treatment or by operation, and often after this is removed the hemorrhoids disappear. If they do not, an operation for their removal should be undertaken.

The treatment of internal hemorrhoids may be palliative or radical. The **palliative** treatment consists in the regulation of the bowels, and, as constipation always aggravates the condition, the patient should be given a saline laxative each morning, sulphate of sodium or of magnesium being the best, to secure a soft movement daily; the use of a small enema of water after each stool may also be followed by good results. An ointment of ext. belladonnæ, gr. x; ext. opii, gr. v; ext. stramonii, gr. xl; ext. hamamelidis, ʒi; adipis, ℥i, can also often be employed with advantage. If hemorrhage is a prominent symptom, an astringent ointment containing tannic acid or persulphate of iron may be smeared over the tumor when it

is prolapsed, or may be introduced into the rectum. Suppositories containing these substances may also be employed.

If a patient suffering from internal hemorrhoids pays attention to the condition of his bowels and uses some of the remedies mentioned, he will often be able to get on comfortably for years without having his piles operated upon. When, however, hemorrhage becomes a prominent symptom and is persistent, nothing short of an operation can entirely relieve the condition.

Radical Treatment.—This may be accomplished by various procedures, among the most important of which are—1, chemical caustics; 2, the injection of coagulating fluids; 3, ligature; 4, the clamp and cautery; 5, excision; 6, electrolysis. Preceding any of the radical operations for internal hemorrhoids, the patient's bowels should be moved by a laxative and the rectum thoroughly emptied by an enema a few hours before the time fixed for the operation. In all cases it will be found advisable to perform the operation under general anæsthesia. After the patient has been anæsthetized he should be placed in the lithotomy position, and the index fingers or the thumbs should be introduced into the rectum and the sphincter thoroughly stretched until it is felt that its resistance has been overcome. (Fig. 808.) *Forced dilatation of the sphincter* is a useful procedure in many rectal operations, and is employed by some surgeons as a curative measure in the treatment of internal hemorrhoids. By this procedure the hemorrhoids can be brought into view and the cavity of the rectum can be inspected. After stretching the sphincter the rectum should be irrigated with a solution of green soap, or may be wiped out with a gauze pad saturated with soap solution, and is finally irrigated with boric acid solution.

Chemical Caustics.—This method of treating hemorrhoids is not now much employed, but, if used, the caustic to be preferred is nitric acid. In small capillary hemorrhoids cauterization with nitric acid will effect a cure, but the application may have to be repeated more than once before the desired result is obtained. It is, therefore, less certain than the ligature or the clamp and cautery, and is not to be preferred to either of these agents.

Injection of Coagulating Fluids.—This method is sometimes employed, tannic acid, extract of ergot, tincture of iron, carbolic acid, and other substances being used. Carbolic acid, from fifteen to fifty per cent., in sterilized glycerin, is the drug upon which most reliance is placed. In the injection treatment, after the hemorrhoids are exposed, two or three drops of the carbolic acid solution are deposited in the centre of the hemorrhoid by means of a hypodermic syringe with a very fine needle. The injections have to be repeated a number of times; the results following this treatment are uncertain, and it is not without danger; inflammation and sloughing of the hemorrhoid may occur, as well as periproctitis. This method is a favorite one in the hands of irregular rectal specialists, and almost every surgeon has seen very unsatisfactory results follow its use. We have seen extensive sloughing of the hemorrhoid, and of the skin in the region of the anus, follow the use of these injections. The method is therefore not to be recommended, and should be employed only in cases in which the patient refuses to take an anæsthetic or to have any more certain operation per-

formed. If employed, care should be taken to have the solution freshly made and the needle and syringe thoroughly sterilized.

The Ligature.—This method of treatment is an old and well-established one, and the results following its employment are very satisfactory. In the operation of ligating hemorrhoids, after the sphincter has been well dilated, a hemorrhoidal tumor is grasped with forceps—ring forceps being the best, as they do not tear the tumor—and a blunt needle attached to a handle is threaded with a double ligature of strong sterilized silk and passed through the base of the tumor and brought out upon the skin surface; the ligature is next divided, and the needle is withdrawn. Before tying, a groove is cut in the mucous membrane at its junction with the skin, in which the ligature is to rest. By this procedure the pain following the tightening of the ligature is diminished. By firmly tying the corresponding ends of the ligature the pile is tightly strangulated in two portions. Care should be exercised that the strangulation of the mass is complete. After the ligature has been secured the ends are cut short, and a portion of the pile may be cut away with scissors, leaving a good stump, so that the ligature cannot slip. The same procedure is repeated until all the hemorrhoids have been strangulated. The stumps are then pushed back within the sphincter, an opium suppository is introduced into the rectum, and a pad of gauze and compress of cotton are placed over the anal region and held firmly in place with a T-bandage. Retention of urine is apt to occur after the ligation of hemorrhoids, and necessitates the use of a catheter for a few days. The ligature may be applied after dissecting the stump of the pile well up in the bowel; the stump is then ligated and the pile cut off, and the wound is sutured below. By this procedure pain and retention of urine are less likely to occur. The patient should be confined to bed for about ten days, and the bowels opened by a laxative and an enema upon the third or fourth day, after which the bowels should be moved on alternate days. Accidents following the use of the ligature are rare; if a ligature slips, bleeding may occur, and a few deaths from tetanus following this treatment have been observed, but these cases of infection can hardly be credited to the use of the ligature. The results following the ligature are satisfactory as regards a cure of the affection, and the only objections to its use are the pain which is often experienced, and the fact that retention of urine is common, calling for the use of the catheter.

The Clamp and Cautery.—This method, which was revived by Mr. Smith, of London, is now very widely employed in the treatment of hemor-

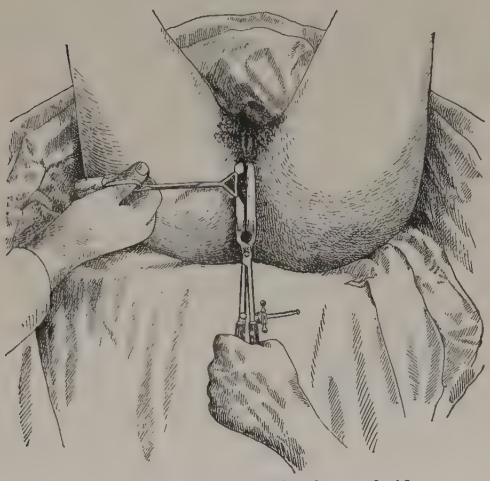
Fig. 815.

Kelsey's hemorrhoid clamp.

rhoids. The instruments required are pile forceps, a clamp, and a cautery iron, or, better, a Paquelin cautery. The clamp we prefer is Kelsey's

(Fig. 815), which is not provided with ivory plates, thus rendering the blades thinner and enabling one to grasp a larger amount of the hemorrhoid—a matter of importance when small growths are being operated upon.

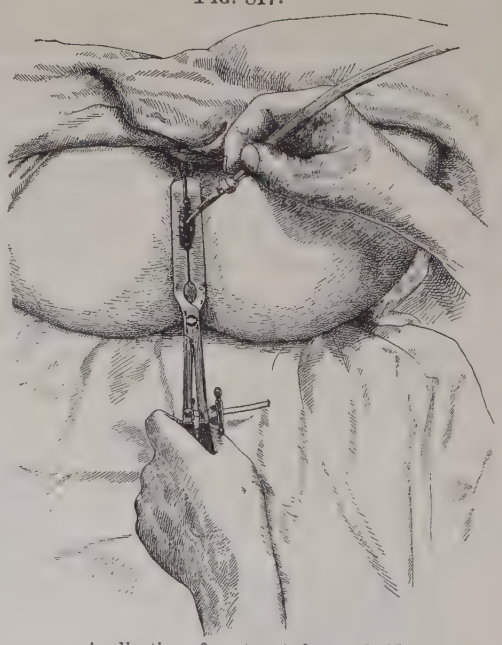
Fig. 816.



Forceps and clamp applied to hemorrhoids.

In operating by this method the hemorrhoid is grasped with forceps and drawn outward; the clamp is then applied to its base, and the handles are firmly pressed together and secured by a screw. (Fig. 816.) The hemorrhoid is next cut off with scissors, leaving a stump extending above the clamp for about one-eighth of an inch. The tumor should not be cut off too close to the clamp. The stump of the tumor is next thoroughly cauterized with the Paquelin cautery at a dull-red heat. (Fig. 817.) In small hemorrhoids it is better not to cut away any portion before applying the cautery. After the hemorrhoid has been thoroughly cauterized. the clamp is gradually loosened, and if any bleeding occurs the cautery is reapplied. This procedure is repeated until all the tumors have been clamped and cauterized. The seared surfaces are dusted with boric acid, or covered with iodoform ointment, and pressed back within the sphincter, and an opium suppository is introduced into the rectum, after which a gauze pad is applied and held firmly in place by a T-bandage. The patient is confined to bed for about ten days, and the bowels are kept quiet until the fourth day, when they are moved by a laxative or an enema. The use of the cautery is not followed by pain, and very seldom by retention of urine, and the results following its employment as regards the permanent cure of the hemorrhoids are most satisfactory. We prefer the clamp and cautery to any of the other methods employed in the treatment of internal

Fig. 817.



Application of cautery to hemorrhoids.

hemorrhoids, considering it much less painful and fully as safe and efficient as the ligature.

Excision.—This method was introduced by Whitehead, and is a very radical one, as it completely removes the whole pile-bearing area.

In this operation an incision is made around the anus a little inside of the junction of the skin with the mucous membrane, and the latter with the hemorrhoidal tumors is dissected up until the upper limit of the hemorrhoids is passed, when they are removed by a circular incision. Vessels which bleed are clamped with hæmostatic forceps or tied during the operation. Weir cuts through some of the hemorrhoidal tissue in the first steps of the operation, instead of dissecting it off, as the piles invade the submucous connective tissue. After all bleeding has been arrested, the wound is irrigated with a bichloride solution, and the mucous membrane is brought down and sutured to the edge of the mucous membrane below by a number of interrupted sutures of catgut or silk. It is important to approximate the edges of the mucous membrane accurately, and if any bleeding occurs between the stitches a few additional points of suture should be introduced. A pad of gauze should next be applied and held in place by a T-bandage. The after-treatment is similar to that employed in case of the ligature or the clamp and cautery, with the exception that the bowels should be kept quiet for a longer time, usually a week. If any skin is removed, the mucous membrane, after healing has occurred, extends beyond the edge of the anus, and is apt to be irritated by the clothing and cause the patient discomfort; and if primary union does not take place, and the wound heals by granulation, stricture of the anus is apt to occur. The results obtained by this method, if carefully done, are excellent; but the operation requires considerable time, and there is often a large quantity of blood lost, so that we do not think it possesses sufficient advantages over the operation by the ligature or by the clamp and cautery to render its general adoption advisable.

Electrolysis has also been successfully employed in the treatment of hemorrhoids, and does not require general anæsthesia or confinement to bed. The method of its application is similar to that employed in the treatment of nævus. It requires the use of special apparatus, and is not very generally practised.

Hemorrhage.—One of the most serious complications after operations for hemorrhoids is hemorrhage. When this occurs, ice should be inserted into the rectum, or it should be packed with iodoform gauze around a large rubber catheter, which will permit the escape of flatus; if the bleeding still continues, the patient should be anæsthetized, the cavity of the rectum exposed by the use of a speculum, and the bleeding point found and secured by ligature, or cauterized with a hot iron or the Paquelin cautery.

ULCERATION OF THE RECTUM.

Ulceration of the rectum of a non-malignant character may arise from a number of causes, and is classified as follows: 1, traumatic; 2, catarrhal; 3, tuberculous; 4, syphilitic; 5, dysenteric.

Traumatic Ulceration.—This condition may arise from wounds accidentally received, or those inflicted upon the rectum in surgical operations,

such as for the relief of hemorrhoids or fistula. In such cases, from not keeping the patient at rest for a sufficient time or from constitutional conditions, healing of the wound may be delayed and an ulcer persist. Foreign bodies in the feces or the pressure of hardened feces may also cause ulceration of the rectum. These ulcerations are generally above the sphincter and cause little pain, and the patient's attention is usually called to the condition by the discharge of a little blood and pus with the stool. A digital examination, or one with the speculum, will disclose the seat of the ulcer.

Catarrhal Ulceration.—This condition may result from acute proctitis, from the impaction of hardened feces in the rectum, from the presence of polypi, or in women may occur from the pressure of a displaced uterus. It is characterized by a sense of fulness and discomfort or pain in the rectum, and by the discharge of a little blood and pus mixed with mucus, and unless relieved by treatment is apt to run a very chronic course. If the rectum is examined with a speculum, ulcers with elevated irregular edges, confined to the mucous membrane and situated well above the sphincter, are found.

Tuberculous Ulceration.—Tuberculous ulceration of the rectum may exist as a primary affection, or it may be secondary to tuberculosis of the lungs or other organs. When a primary affection, it may result from direct inoculation, from contact of food which contains tubercle bacilli, or, as has been pointed out by Klebs, from the swallowing of sputa containing these organisms. In tuberculous ulceration of the rectum the ulcers are undermined and irregular, and marked infiltration of the mucous membrane is present. The ulcers have a tendency to perforate the coats of the bowel, by reason of which the formation of sinuses and fistulæ is a frequent complication. *Symptoms.*—In this affection pain is not usually marked, and the condition may exist for some time before the patient's attention is directed to the rectal disease. A slight discharge of blood and pus with the stool sooner or later occurs. If a patient suffering from tuberculosis of other organs presents these rectal symptoms, the nature of the trouble should be suspected.

Syphilitic Ulceration.—Syphilitic ulceration of the rectum occurs late in the disease, and often results from the breaking down of a gumma. It is accompanied by the usual symptoms of ulceration of the rectum, and runs a very chronic course. In all cases of chronic ulceration of the rectum the patient should be carefully examined to ascertain if he has had syphilis.

Dysenteric Ulceration.—Ulceration of the rectum following dysentery, especially if the latter affection has been of a chronic form, is occasionally met with. The ulceration in these cases appears to originate in the solitary follicles. The symptoms presented are those common to ulceration of the rectum. This variety of ulceration, if extensive, may subsequently cause stricture of the rectum.

Treatment.- The general treatment of ulceration of the rectum is applicable to all the varieties, and consists in absolute rest in bed, usually for some weeks, and careful regulation of the diet to prevent irritating material in the feces from coming in contact with the ulcerated surfaces. A diet composed of milk and animal broths is the best. The bowels should also be regulated so that soft movements are obtained, saline laxatives being

administered. The local treatment of the ulceration may be accomplished by the use of enemata or suppositories, or by direct applications made to the ulcerated surface. The latter method requires the use of a speculum, which is painful and should be avoided except in special cases.

In cases of traumatic, catarrhal, or dysenteric ulceration, the use of an enema of bismuth. subnit., gr. xx ; tr. opii, ♏x ; mucil. acaciæ, f℥ii, morning and evening, or of a solution of argenti nitratis, gr. vi ; aquæ, f℥ii, may be followed by good results ; or the following suppository may be used morning and evening in place of the enema : pulv. opii, gr. ss ; pulv. iodoformi, gr. v ; ol. theobrom., q. s. It is sometimes desirable to make direct applications, in which case a solution of nitrate of silver, gr. v to x to the ounce, should be gently brushed over the ulcerated surfaces. In tuberculous ulceration the best results are obtained by carefully curetting the ulcerated surface and subsequently touching it with a ten-grain solution of nitrate of silver, and by the daily use of suppositories containing iodoform. If the treatment is applied early in tuberculous ulceration, perforation of the bowel and the formation of fistulæ may be avoided. In this form of ulceration the administration of tonics and cod-liver oil is often of the greatest benefit. If, however, fistulæ already exist, these should be laid open and curetted. Syphilitic ulceration should be treated by the local use of nitrate of silver and iodoform, and at the same time iodide of potassium, alone, or combined with biniodide of mercury, should be administered internally.

Encysted Rectum.—This is a rectal affection occasionally observed, consisting in ulceration and occlusion of the lacunæ or sinuses of Morgagni, which are situated just above the external sphincter. The symptoms of the affection are pain and discomfort in the rectum, the pain not usually being so severe as in the case of fissure. The treatment consists in exposing the lower portion of the rectum with a speculum, when the distended or ulcerated sinuses may often be seen. A probe bent in the form of a hook should be passed into these sinuses, and they should be laid open, which causes their obliteration, and is usually followed by relief of the symptoms.

Non-Malignant Stricture of the Rectum.—Strictures of the rectum, independent of those resulting congenitally, which have already been considered, and those due to cancer and the presence of tumors outside of the bowel, may result from the cicatrization and contraction following wounds, or from extensive ulceration of the rectum following proctitis, sloughing, dysentery, tuberculosis, chancroid, or syphilis. Spasmodic stricture of the rectum, aside from spasmodic contraction of the sphincter muscle, is a rare affection, but a few well-authenticated cases have been reported in which this condition existed. These strictures are said to be more common in females than in males, and are generally observed in adults.

The stricture may consist of a ring-like constriction or a narrowing of the tube several inches in length. The mucous membrane is often ulcerated at the seat of stricture and is replaced by dense cicatricial tissue. In stricture of the rectum due to the presence of external growths the mucous membrane is generally normal. Marked dilatation of the bowel above the seat of stricture is usually present, and the walls of the bowel may be so thin that

rupture may occur. (Fig. 818.) The formation of fistula in connection with stricture is often observed.

Symptoms.—The symptoms of stricture may not be marked until the contraction of the rectal canal is well advanced, and consist of slight morning diarrhœa and the discharge of a little bloody mucus and thin brown fluid. The tape-like shape of the stool is supposed to be characteristic of stricture, but this is not always the case, for in strictures high up in the canal the feces may accumulate in the bowel below the stricture and be passed in large masses. Stricture of the rectum may cause death by complete obstruction of the bowels, or by rupture of the bowel above producing peritonitis, or the patient may be worn out by long-continued irritation and suppuration resulting from the affection.

Fig. 818.

Non-malignant stricture of the rectum. (Agnew.)

Diagnosis.—Stricture of the rectum can usually be recognized by a digital examination, and its differentiation from malignant growth is made by observing the following conditions. It is a disease of adult life, and exists a long time without producing constitutional disturbances; the mucous membrane, if present, is not indurated, and pain is usually complained of only during the act of defecation.

Treatment.—This may be either constitutional or local. Stricture of the rectum due to gummatous infiltration of the anus or the rectum, which is a comparatively rare affection, may disappear under the use of mercury and iodide of potassium, but that resulting from the cicatrization of chancroidal or gummatous ulceration is not affected in any way by constitutional treatment.

Internal incision is attended with so much danger that it is rarely employed. **Dilatation.**—When the stricture is situated well down in the rectum, dilatation may be accomplished by the use of the finger or of bougies, and the best bougie to use for this purpose is a soft rubber one. In using bougies extreme gentleness should be exercised in their manipulation, and the dilatation should be very gradual; forcible dilatation is a dangerous procedure, and should not be employed. Their use is always attended with some risk of rupture of the gut, as very little force may rupture a thin portion of the wall of the gut in connection with a stricture. This accident may cause no pain, and cases have occurred in which neither the surgeon nor the patient was aware of its occurrence at the time. By gradual dilatation the canal may be so much increased in size that obstructive symptoms disappear and the patient experiences great comfort, but a permanent cure of the stricture does not result, so that the regular passage of the bougie should be practised to maintain the dilatation.

Linear proctotomy, or external incision, is employed with advantage in strictures where the passage of the bougie is followed by great pain and

constitutional disturbance, or where the dilatation cannot satisfactorily be accomplished by its use. In performing this operation the patient should be anæsthetized and placed in the lithotomy position. After washing out the rectum below the stricture and sterilizing the skin of the anal region, an incision is made directly backward to the hollow of the sacrum, through the anus, posterior rectal wall, and stricture; after irrigating the wound it is loosely packed with strips of iodoform gauze, and allowed to heal by granulation. As the sphincter has been divided, incontinence results, and drainage is free, so that extravasation of feces into the cellular tissue does not occur. The relief of obstruction resulting from this procedure is complete, but as healing occurs narrowing may again take place, so that a full-sized bougie should occasionally be passed until the wound is cicatrized.

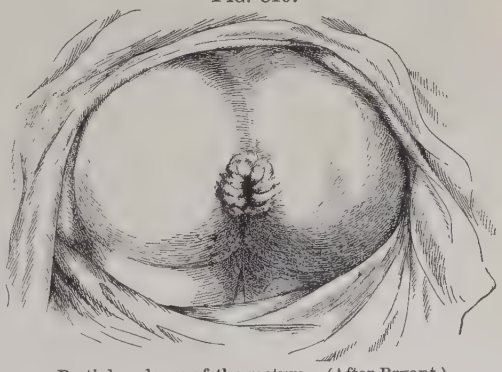
Excision.—In strictures situated low down in the rectum excision has been practised with success, and is accomplished in the same manner as when the rectum is excised for the relief of cancer. The operation will be described under cancer of the rectum. This operation, when it can be done, is preferable to linear proctotomy, as it leaves the patient with control of the sphincter.

Colostomy.—This operation is probably the best and safest that can be performed for the relief of stricture of the rectum, and the iliac is to be preferred to the lumbar operation.

Prolapse of the Rectum.—This affection presents three distinct varieties. 1. The mucous membrane alone may be prolapsed and protrude from the anus, known as partial prolapse. 2. All the coats of the rectum, including the peritoneum, if the protrusion is extensive, may protrude from the anus (complete prolapse). 3. There may be invagination of the intestine, as well as prolapse, producing an external intussusception.

Partial Prolapse.—In this form the mass protruded consists of the mucous membrane of the lower portion of the rectum, the other coats of the bowel remaining in their normal position. (Fig. 819.) This variety of prolapse of the rectum is of frequent occurrence. Its comparative frequency is explained by the anatomical fact that the submucous connective tissue is loosely attached to the walls of the rectum. A slight protrusion of the mucous membrane may be produced voluntarily, and occurs normally during defecation. Partial prolapse is frequent in childhood, is rarely seen between the ages of fifteen and fifty, and is comparatively frequent in the aged.

FIG. 819.



Partial prolapse of the rectum. (After Bryant.)

Causes.—This condition may arise from inflammatory effusions into the submucous connective tissue, as in catarrhal proctitis or dysentery;

the presence of hemorrhoids or of polypi, which have a tendency to drag the mucous membrane downward and also to produce severe straining; severe and long-continued efforts in defecation in cases of obstinate constipation, or straining efforts from obstruction to the free passage of urine from the bladder, caused by a tight phimosis, a vesical calculus, a stricture of the urethra, or an enlarged prostate.

In children the presence of angular flexures in the lower part of the colon, requiring severe straining to produce fecal evacuations, and the straightness of the coccyx, are anatomical factors which tend to its production. Improper diet and overfeeding, and the custom of allowing children to eat continually through the day, as a result of which there occur a large number of passages, may also give rise to this affection. We have often seen children sent to the hospital for operation in whom, after a few days' stay, with a properly regulated diet, the prolapse failed to appear at stool, and often could not be made to appear even with the use of enemata. The practice, so common with mothers and nurses, of keeping the child upon the chamber utensil for a long time tends to the production of prolapse.

Symptoms.—The most marked symptom of this affection is the protrusion during defecation of a red mass, composed of folds of mucous membrane with sulci between them. The protrusion is usually unaccompanied by pain, and generally undergoes spontaneous reduction as soon as the straining efforts cease. If, however, the prolapsed mucous membrane is allowed to remain out for a time, it may become congested, or even ulcerated, and some difficulty may be experienced in its reduction.

Diagnosis.—In cases of partial prolapse the diagnosis is usually not difficult. The appearance of the folds of mucous membrane with a central depressed orifice is characteristic. The condition may be confounded with hemorrhoids or with polypus of the rectum, but a careful examination will reveal its true nature.

Complete Prolapse.—This condition, which consists in the protrusion of all the coats of the rectum, usually develops gradually from cases of partial prolapse which have existed for some time, but may develop suddenly as the result of violent expulsive efforts. When the protrusion reaches a considerable size the possibility of the peritoneum being included in the mass should always be remembered, and, owing to the fact that the peritoneum descends lower upon the anterior than upon the posterior surface of the rectum, it is more apt to be found in the anterior portion of the mass. In some cases the prolapsed mass is very large, and cases have been observed in which the greater part of the colon was included in the protrusion. The appearance of complete prolapse is very characteristic—the semi-ovoid tumor covered with mucous membrane, the sulci parallel to the anus (Fig. 820), and the greater size of the mass serving to distinguish it from partial prolapse.

Treatment.—The treatment of prolapse of the rectum is either palliative or radical. The palliative treatment consists, first, in the reduction of the mass. This can generally be accomplished best by placing the patient upon his stomach and making gentle pressure upon the central portion of the

mass with the greased finger, or with a piece of soft muslin which has been well oiled, when it can usually be reduced without difficulty. After reduction various methods may be employed to prevent the recurrence of the prolapse. The patient should have the bowels moved upon a bedpan or while resting upon the side. In the case of children the nurse should be instructed to draw the skin of the anus to one side during the passage of the feces. The local use of astringent injections of tannic acid or oak bark may be employed with advantage, or the protruded mass may be washed with a solution of alum, ʒi ; water, ℥viii ; or one of tinct. of iron, ♏xxx ; water, f℥iv. The diet should be also regulated. If, however, the bowel continues to protrude with each act of defecation, radical means for the cure of the affection should be undertaken, for it is to be remembered that an unrelieved partial prolapse may gradually develop into a complete one.

Fig. 820.

Complete prolapse of the rectum. (After Agnew.)

Radical Treatment.—This may be accomplished by cauterizing the mass with nitric acid, the actual cautery, or the clamp and cautery, or by excision of the prolapsed tissue. **Cauterization with Nitric Acid.**—In prolapse of the rectum in children cauterization with nitric acid usually results in a cure. The patient should be given an enema to wash out the rectum and bring down the prolapse ; an anæsthetic should next be given, and, after the surface of the protruded mass has been carefully dried with cotton or a soft piece of muslin, the skin surrounding the anus should be rubbed over with vaseline or oil and the surface of the prolapsed mass painted over with nitric acid, applied by means of a swab, care being taken that the acid does not come in contact with the skin. After the mucous membrane has been painted over with the acid it becomes of a whitish-yellow color. The cauterized surface is next gently smeared over with boric acid ointment, and the mass is reduced. A small pad of gauze or cotton is placed over the anus, and is held in place by bringing together the buttocks with one or two wide strips of adhesive plaster.

The bowels are allowed to remain quiet for a day or two, and are then moved by a saline laxative or a dose of castor oil. At the first motion the bowel may protrude. If this is the case, it should be reduced and a compress applied over the anus. One application usually results in a cure, but it is sometimes necessary to resort to a second cauterization in cases of extensive prolapse. Although this method of treatment is satisfactory in children, it is not followed by as good results in adults.

Actual Cautery.—This is the most satisfactory method of treatment for rectal prolapse in adults. The patient is anæsthetized and placed in the lithotomy position, or upon his side with the limbs flexed, and the cautery is applied to the unreduced mass, three or four lines being made from the apex of the tumor to the sphincter at different points, the deepest eschars being made at the sphincter, and large veins being avoided. The prolapse

is next reduced, an opium suppository is introduced into the rectum, and a pad is applied to the anal region and held in place by a T-bandage. The bowels should be moved by a saline laxative on the third day, and after this time daily evacuations encouraged, and the patient kept in bed on restricted diet until the ulcers have healed. The actual cautery may also be applied in the treatment of prolapse in children, a small cautery point being used and the lines of cauterization being more superficial.

Clamp and Cautery.—This method of treatment may be employed in prolapse of the bowel, and seems to be especially useful in cases of persistent partial prolapse where there is marked induration of the prolapsed mass with difficulty in its reduction. In extensive prolapse care should be taken not to clamp the mass too near the sphincter, so as to avoid the danger of including the bowel or the peritoneum in the grasp of the clamp. The operation consists in grasping longitudinal sections of the mass at different points in the clamp, and applying the cautery iron thoroughly to the clamped portions.

Excision.—Circular excision of the prolapsed mass has been employed with success in a number of cases of prolapse of the rectum. The operation should, however, be reserved for extensive and irreducible cases. In this operation, after removing the mass by a circular incision, the edges are secured by sutures without difficulty, as they are already in contact. Excision of elliptical strips of mucous membrane from different portions of the mass has also been practised with good results.

Prolapse with Invagination of the Intestine.—In this condition there is present in the rectum, or escapes from the anus, a portion of the upper intestine which has been invaginated. No true prolapse of the rectum occurs in these cases, for the bowel at the anus remains stationary and the intestine above is telescoped within it. The possibility of the existence of this condition should always be borne in mind in examining tumors which protrude from the anus.

Symptoms.—The symptoms of this condition are the escape of blood and mucus from the anus preceding the appearance of the tumor, and the development of signs of obstruction of the bowels, with the attendant constitutional symptoms. The affection is a most serious one, and is always fatal unless the obstruction be removed by operative treatment or sloughing of the intussusceptum.

Treatment.—The patient should be anæsthetized and attempts made to reduce the invaginated gut by manipulations or by injections. If it cannot be reduced, an artificial anus should be made in the left or right groin by inguinal colostomy, or resection and suture of the prolapsed mass should be undertaken. The method of Mikulicz may be employed, which consists in placing the patient in the lithotomy position, making a transverse incision through the anterior portion of the prolapse, dividing the serous surface of the intussuscipiens, and exposing the serous surface of the intussusceptum. The two serous membranes should be sutured together by fine silk sutures, which shut off all communication with the peritoneal cavity. The anterior portion of the intussusceptum is then cut through in advance of the line of sutures, and the two ends of the gut are approximated with silk

sutures. After securing the periphery of the two intestinal openings and tying numerous mesenteric vessels, a few additional deep sutures are introduced, and after dusting the wound with iodoform the stump of the prolapse is returned. The bowels should be kept confined for a week by the use of opium. Colostomy seems to be the safer procedure, and a subsequent operation on the prolapsed gut may be done if the intussusceptum is not removed by sloughing.

BENIGN GROWTHS OF THE RECTUM.

Polypus.—This term is applied to certain benign tumors growing from the rectal wall, to which they are attached by a more or less well formed pedicle. These may exist as either adenomatous, fibromatous, or papillomatous growths, and are comparatively rare affections. Other tumors, such as lipoma, cystoma, myoma, chondroma, and lymphoma, are occasionally observed.

Adenoid Polypus.—This form of growth, which is usually attached to the wall of the rectum by a narrow pedicle, presents a red irregular lobulated surface, and may vary in size from that of a pea to that of a walnut. (Fig. 821.) The growth may be single, or a number may exist in the rectum at the same time. If the growth possesses a sufficiently long pedicle, it may be protruded from the anus during defecation, and, owing to the constriction of its circulation by the sphincter, may present a dark purple color. This is the form of polypus which is usually seen in children, but is a quite rare affection. The growth originates in an hypertrophy of the follicles of Lieberkühn, and the overlying mucous membrane is gradually stretched so as to form a pedicle.

Fig. 821.

Adenoid polypi of the rectum. (After Ball.)

Fibroid Polypus.—This is a benign tumor, of the connective-tissue type, which may be found attached to the wall of the rectum by a pedicle. It usually has its origin low down in the rectum, and probably often originates from internal hemorrhoids, is often multiple, and may attain considerable size.

Villous Polypus.—This is a papillomatous growth which is occasionally found growing from the walls of the rectum, and presents much the same appearance and structure as the villous tumor of the bladder. It originates from the papillæ of the mucous membrane, and is covered with columnar-celled epithelium.

Symptoms.—Polypus may exist for a long time without giving rise to any definite symptoms, although then the patient may experience a sense of fulness in the rectum which is not relieved by defecation. Its presence, however, is sooner or later manifested by the discharge of mucus and blood. The latter may be only a few drops, or profuse bleeding may be present. If the polypus is caught by the sphincter, discomfort or pain is experienced. The constant escape of blood and mucus without pain should

cause the surgeon to suspect the presence of polypus. An examination of the rectum with the finger or with a speculum will locate the growth. The use of an enema before the examination is of advantage, as it empties the rectum of fecal matter and tends to bring the polypus nearer the anus.

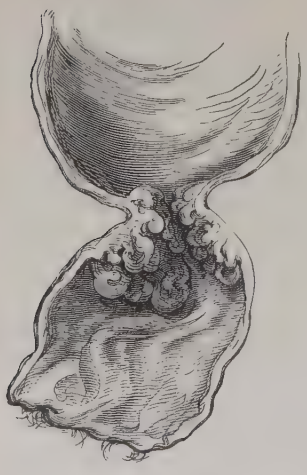
Treatment.—The patient should be anæsthetized, and, after stretching the sphincter, if the polypus has a fairly long pedicle it comes into view; the use of the speculum may be required to expose it if it has a short pedicle or is attached to a high portion of the rectal wall. If the growth is small and well pedunculated it may be grasped with forceps and twisted off, as the bleeding is not often troublesome, or its pedicle may be divided and the actual cautery or nitric acid applied to the stump. Ligation of the pedicle near its origin from the rectal wall is, however, the safest procedure before the pedicle is divided. Care should be taken not to make so much traction upon the pedicle as to invert the rectal wall at its point of attachment, for if this were done it might be included in the ligature or incision. If multiple polypi exist, the same procedure is repeated for each growth. When the growths are sessile and involve a considerable portion of the rectal walls, they should be removed by curetting, and the surface left should be lightly touched with the actual cautery or nitric acid.

The after-treatment, if the growths are numerous or involve a large surface of the rectum, consists in the use of an opium suppository and rest in bed for a few days, the bowels being kept in a soluble condition.

MALIGNANT GROWTHS OF THE RECTUM (CANCER).

Malignant growths of the rectum vary considerably in their characters, and may present themselves as *epithelioma* of the squamous type, which has its origin in the skin or the mucous membrane of the anus and spreads to the rectum; *columnar-celled epithelioma*, sometimes described as *malignant adenoma*, which arises from the mucous membrane of the rectum (Fig. 822) and is the most common variety; *scirrhus*, or hard cancer, which infiltrates the submucous connective tissue of the rectum; *colloid*, or alveolar cancer, which has its origin in the follicles of Lieberkühn, or the rectal crypts; and *encephaloid*, which develops in the glandular tissue of the mucous membrane. Sarcomata are also met with in the rectum, but they are much less frequent than the various forms of cancer. Sarcoma of the melanotic type has been observed.

Fig. 822.



Malignant adenoma of the rectum. (Agnew.)

Symptoms.—The symptoms of rectal cancer vary greatly in individual cases, and often resemble those of hemorrhoids, but the most frequent symptom is diarrhœa, which is often the earliest to attract attention, and which may alternate with constipation or the escape of small, firm, fecal masses resembling sheep's feces. Any case of chronic diarrhœa in the adult should be

looked upon with suspicion, and a rectal examination should be made. Pain is sometimes an early symptom, but may not be marked until the disease is well advanced. It is more apt to be noticed early in the disease, when the anus and the lower portion of the rectum are involved. It may be severe in the later stages of the disease, when the growth presses upon the sacral plexus, and may be confounded with sciatica, or may arise from obstruction of the bowel, in which case it is apt to be paroxysmal and is accompanied with efforts at defecation.

Bleeding may exist at any stage of the disease, and is seldom free except in the latter stages of the affection. Its presence shows that ulceration of the growth has taken place, the escape of feces, pus, and blood being a very common symptom. When the disease is well advanced and the sphincter has lost control and the anus is patulous, or when fistulæ exist, a thin fetid discharge constantly escapes, soiling the clothing, and producing often severe irritation of the anal region. Obstruction due to narrowing of the rectum may result from the growth of the neoplasm into the canal or from cicatricial contraction of the wall of the gut. This symptom may appear early in the disease, but is most likely to be a late one, and is not observed in every case. We have seen cases in which the rectum and surrounding tissues and organs were extensively involved and yet obstruction was not marked. Tenesmus and straining are common symptoms as soon as the obstruction occurs. Complete obstruction may exist, and only occasionally results in fecal vomiting ; it, however, causes pain and abdominal distention, and may exist for some days, when an escape of thin feces occurs from the rectum, or the obstruction may be relieved by the formation of a fistulous opening into the vagina, bladder, or rectum, or upon the skin in the anal region. When the obstruction is complete and not relieved, death may result from peritonitis following perforation of the gut at some point above the stricture. Involvement of the lymphatic glands may occur early in the disease, and is usually very marked. Pressure of the growth upon the iliac vein may cause œdema of the leg. The duration of the disease is usually from two to three years, but if obstruction is a marked symptom the disease may run a shorter course unless this condition is relieved by surgical interference.

Diagnosis.—A careful digital examination should be made in all cases which present any of the symptoms of cancer of the rectum, and in the majority of cases a hard nodular mass, a soft growth extending into the rectal canal, or a well-marked stricture can be felt. If a digital examination is made with the patient standing and straining, a growth may be felt by the finger which cannot be reached in the recumbent position. No attempt should be made to force the finger through the narrowed canal to ascertain the extent of the growth, as such a procedure has been followed by perforation of the bowel ; the use of bougies for this purpose is accompanied by even greater danger. At the time of examination the region of the hollow of the sacrum should be examined through the rectal wall for the presence of enlarged glands, and attempts should be made to ascertain if the rectum is movable or is firmly fixed to surrounding structures.

Non-malignant stricture, or a tumor pressing upon the rectum, is the condition which is likely to be confounded with cancer of the rectum. In

non-malignant stricture of the rectum the development of symptoms is very slow, and upon examination the absence of nodular masses, so common in cancer, is noted. In stricture of the rectum from tumors pressing upon the gut, upon the introduction of the finger into the rectum it will be observed that the mucous membrane is healthy and is freely movable. The peculiar cachectic appearance which is common to malignant disease soon develops in malignant disease of the rectum, particularly if there is free bleeding, and is not observed in non-malignant stricture, even of long duration.

Treatment.—The treatment of malignant disease of the rectum depends upon the stage at which the disease is seen and the extent to which the disease has involved the rectum and surrounding tissues. Many cases come under the care of the surgeon who absolutely refuse to have an operation done, or in whom the disease has involved the tissues so extensively that no operative treatment of the growth is justifiable. In such cases the surgeon must consider the treatment which is most likely to render the patient's condition comfortable or bearable until the fatal termination of the affection. Opium, in the form of suppositories, or morphine hypodermically, sooner or later has to be resorted to. Its use is indicated as soon as the pain is severe, but the quantity employed should be regulated by the surgeon, so that the patient shall not acquire the opium habit early in the disease. The diet should be carefully regulated to diminish the quantity of the fecal matter, and the occasional use of purgatives may be required.

The **operative** treatment of cancer of the rectum should be restricted to excision of the growth, or to the establishment of an artificial anus by the operation of colostomy, which may be considered in the light of a palliative procedure. Such procedures as linear proctotomy, curetting the growth, and the application of caustics, result in little benefit, and cannot be recommended. The use of rectal bougies in rectal cancer is attended with so much danger and so little benefit that they should never be employed.

When operative treatment is decided upon, the choice of operation should rest between excision of the rectum and colostomy. The latter operation should not be delayed until it is performed to relieve intestinal obstruction, but should be employed as soon as symptoms of obstruction appear. When the presence of rectal cancer is recognized, if operative treatment is decided upon, one of these operations should be performed.

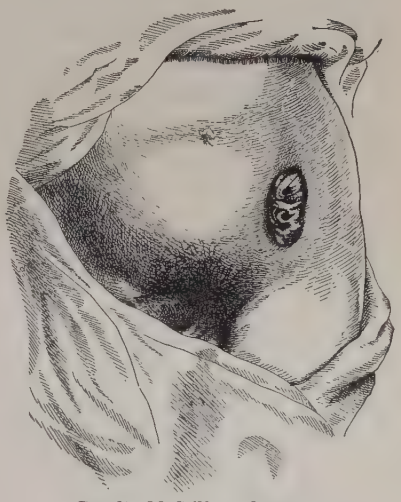
Great diversity of opinion exists among surgeons as to whether excision or colostomy is the better operation, and the question is undecided. Excision, if undertaken early, is followed by most encouraging results, but the immediate risk of the operation is great, and recurrence usually takes place within a year or two.

Excision of the rectum, in selected cases, is now being more widely employed, and should be practised in limited movable growths unless there are signs of secondary deposits in the glands or in the liver, and although the results of the operation are more favorable under aseptic precautions, Curtis reporting about twenty per cent. of cures, still a considerable mortality results from shock, hemorrhage, or sepsis, probably about fifteen per cent.

In cases in which obstruction exists, left iliac colostomy should be performed, and if done so as to establish an artificial anus, through which all the feces escape, and not merely to form a lateral outlet to the bowel, permitting a portion of the fecal matter still to find its way into the rectum, where its presence causes great discomfort, is an operation which will be followed by the greatest benefit. A patient with an artificial anus may often live in comfort for years and be able to go about and attend to his business, suffering little inconvenience from involuntary fecal discharges, unless the bowels are very loose, and at the same time the activity in the growth of the tumor often seems to be diminished by the ablation of the function of the rectum.

Colostomy.—This operation, which should be undertaken with the idea of forming an artificial anus and not a fecal fistula, may be performed in the left or the right iliac region or in the left lumbar region. In the latter position it is possible to prevent part of the feces from still entering the bowel below the artificial opening, and therefore left iliac colostomy is to be preferred. (Fig. 823.) In exceptional cases the operation may be done in the right iliac region. For details of this operation, see page 950.

Fig. 823.



Result of left iliac colostomy.

Excision of the Rectum, or Proctectomy.—The cases of cancer of the rectum which are considered most favorable for this operation are those in which the disease does not involve the rectum beyond the reach of the finger, and in which it involves the posterior rather than the anterior wall. In the latter situation, involvement of the bladder, prostate, urethra, or vagina may seriously complicate the operation.

For this operation the patient should have the bowels freely opened by a laxative on the morning of the operation, and a few hours before he is anæsthetized the lower bowel should be washed out with warm water or a solution of boric acid. The patient, having been anæsthetized, is placed in the lithotomy position, with the pelvis slightly elevated.

If the lower portion of the rectum, including the anus, is involved, a circular incision should be made around the anus well outside the limits of the disease, and should be supplemented by an incision from the posterior portion of the anus to the coccyx. The dissection should then be carried deeply into the ischio-rectal fossa, the attachments of the levator ani muscles being divided. The most difficult part of the dissection is the separation of the anterior portion of the rectum from the vagina, urethra, and bladder. This should be accomplished with blunt scissors and the finger. It is well, in the male, to introduce a sound into the bladder, to serve as a guide during the dissection. In the female the finger may be placed in the vagina as a guide. When the dissection has been carried up to a point above the

disease, the bowel should be divided transversely at this point with scissors. If the peritoneal cavity is opened in the dissection, it should be closed by sutures. Vessels which bleed freely during the dissection should be clamped with hæmostatic forceps and finally ligatured. The wound is next irrigated, and the edges of the bowel brought down and sutured to the skin, care being taken to pass the sutures deeply, so that no pockets shall be left in which fluids may collect and become septic. A drainage-tube is also introduced if the posterior portion of the incision is closed by sutures.

In cases where the anus is not involved in the disease the incision should be made in the same manner, but the sphincter should be divided posteriorly and turned aside with the skin. If a portion of healthy mucous membrane is present, it should be left. A large rubber catheter wrapped with iodoform gauze is passed into the bowel, and its end left projecting from the anus to permit the escape of flatus. This tube is often not well borne, and has frequently to be removed soon after the patient recovers from the anæsthetic. A gauze dressing is placed over the anal region and secured by a T-bandage. The patient should be placed upon a liquid diet, and the bowels kept quiet by the use of opium. At the end of a week the bowels are moved by a laxative and the tube is removed.

To avoid the trouble which often arises from fecal movements soon after the operation, and to enable the surgeon better to keep the wound aseptic, a preliminary inguinal colostomy is sometimes done on the left side, and when this wound is healed and the feces are escaping from the artificial anus the excision of the rectal growth is undertaken.

Kraske's Operation.—When cancer involves the rectum high up, even as high as the sigmoid flexure, it is possible to excise the growth by an operative procedure, which has been described by Kraske. This consists in making an incision from the second sacral vertebra to the anus, and dividing the muscular attachments and ligaments on the left side of the sacrum as far as its end. The coccyx should also be excised, and a portion of the left side of the sacrum removed with a gouge. The incision should next be carried forward so as to encircle the anus. This gives a free exposure of the rectum, which is then dissected loose from its attachments. The peritoneal cavity is opened, and the gut is drawn down and amputated by a circular incision. The edges of the gut are next brought down as far as possible and sutured to the tissues of the ischio-rectal fossa. A drainage-tube should be placed in the peritoneal cavity, its end projecting from the perineal wound. The wound is packed with gauze, and a gauze dressing applied.

Schede recommends closing the peritoneal cavity by the application of sutures, uniting the peritoneum to the serous surface of the sigmoid flexure. He also recommends leaving the anus and the lower portion of the rectum intact, if healthy, and suturing the lower rectal segment by two layers of sutures, one passed through the mucous coat and the other through the other coats of the bowel. Preliminary colostomy in the left groin is also practised before the rectum is excised.

Recto-Vesical, Recto-Urethral, and Recto-Vaginal Fistula.—These various forms of fistula as congenital affections have already been described, but they may also result from traumatisms in the female, as acci-

dents of parturition and wounds received in operations upon the rectum, vagina, bladder, or urethra. Recto-urethral fistula occasionally results from the operation of lithotomy, or from rupture of the urethra following stricture. But the most frequent cause of these fistulæ is malignant disease of the rectum, the growth involving one of the contiguous organs.

Treatment.—In accidental wounds of contiguous organs made in operations upon the rectum, the wounds should be promptly closed by sutures, and in the majority of cases rapid union occurs, so that no permanent fistula results. Where, however, a fistula persists, a plastic operation must be undertaken to close the fistula, except in cases resulting from cancer of the rectum, where no operation is likely to be of any service. A recto-vaginal fistula in the latter cases often is followed by the relief of pain and tenesmus and abatement of the symptoms of obstruction. A recto-vesical or recto-urethral fistula, on the other hand, may cause so much pain and discomfort that the patient's condition can be improved only by making an artificial anus in the iliac region.

CHAPTER XXXVI.

VENEREAL DISEASES.

SYPHILIS.

Syphilis is a constitutional disease, chronic in type, attended by lesions the nature of which includes it in the class of infectious granulomata with leprosy and tuberculosis. It may be hereditary or acquired, and is propagated by contagion, the virus being present in the secretion of the initial lesion, the blood, and the secretions of the lesions of the secondary and the active stage of the hereditary form of the disease. The lesions of the tertiary stage are probably not contagious, nor are the normal secretions, as the milk, tears, etc., unless contaminated by the blood or by the discharge from a syphilitic lesion. In the acquired form of the disease the method of contagion may be *immediate*—that is, by direct contact between the infected and infecting parties, as in sexual intercourse; or *mediate*, where the poison is carried by something acting as a vehicle of contagion. The latter method is by no means uncommon, through the use of table utensils, pipes, glass-blowers' implements, drinking-vessels, etc. Formerly syphilis was sometimes transmitted by vaccination with humanized virus, by the admixture of blood with the lymph from the arm of a syphilitic child.

Etiology.—The nature of the infection has not yet been discovered. All the symptoms of syphilis point to its being of bacterial origin, and a bacillus has been described by Lustgarten, but no germ has yet been proved to be the cause of the disease. After the entrance of the poison into the system there elapses a space of time, the "primary period of incubation," during which there are no local or general symptoms. This period has an average length of three weeks, although chancre has developed as early as seven days and as late as ten weeks after inoculation. At the end of this time the local sore appears. Syphilis is divided into three stages, the *primary*, the *secondary*, and the *tertiary*.

Chancre, or Initial Lesion.—The acquired form of syphilis is invariably ushered in by an initial lesion at the site of the infection. There is one alleged exception—that is, where a mother is supposed to acquire the disease from a syphilitic fœtus in utero, without previous inoculation from the father, such infection being proved by the subsequent appearance of constitutional symptoms; but in these cases there is always the possibility that the chancre has been present and overlooked.

The chancre ushers in the primary stage, is always situated at the spot where the virus gains admission to the body, and, as the most common means of communication is by sexual intercourse, it is in the large majority of cases found on the genitalia. As remarked above, however, syphilis is

PLATE IV.

1. Chancre of the lip. 2. Venereal warts. 3. Chancre of the thumb. 4. Chancroids. 5. Gonorrhœa. 6. Chancre.

often communicated in an innocent manner, and extragenital chancre is, therefore, not uncommon, constituting ten per cent. of the whole number according to Bulkley. An abrasion of the surface is generally necessary, although it is asserted that the inoculation can take place on a sound surface, the virus penetrating the epithelium or travelling down a hair or sebaceous follicle.

When situated on the genitals, the favorite seats of chancre are the inner layer of the prepuce and the balanopreputial furrow. It occurs also on the glans, the skin of the penis, at the meatus, which it generally surrounds, although it may occupy either lip, and in the urethra itself, where it occasions a discharge and may simulate gonorrhœa. In women it is situated on the labia, fourchette, prepuce, and clitoris, rarely in the vagina and on the cervix uteri. Extragenital chancres may occur upon any part of the body, but are most common on the lip (Plate IV., Fig. 1), the tongue, and the tonsil, on the finger (Plate IV., Fig. 3) in surgeons and obstetricians, and on the nipple in nursing women. The chancre may occur in one of several forms. It appears as the chancrous erosion (the most common variety), the deep ulcerating (Hunterian) chancre, and the dry papule (Lancereaux). Other rare forms are the silvery spot, the follicular or umbilicated chancre, and the necrotic nodule. The *chancrous erosion*, the form most commonly seen, appears as a smooth polished surface denuded of epithelium, dull red, seldom excavated, but sometimes covered by a thin greenish membrane, and furnishing a scanty serous or sero-sanguineous discharge, contagious in character. In the *ulcerating chancre*, which follows ulceration of the ordinary variety, there exists an excavated surface with sloping edges and a gray base, the discharge being sero-purulent. The *Hunterian chancre* is one in which the ulcerative process has gone on to the production of a deep funnel-shaped ulcer, surrounded by much induration, and with a base often covered by grayish membrane. (Plate IV., Fig. 6.) It is believed by some, probably incorrectly, to be associated with a virulent form of syphilis. The *dry papule* occurs on a dry surface, and hence is common on the skin, where, owing to lack of moisture, it does not ulcerate, but remains as a papule with a dry desquamating surface. A constant feature of the chancre is a characteristic induration, hard and circumscribed to the touch, very different from the inflammatory thickening around an inflamed chancroid, and due to a round-cell infiltration in and around the ulcer and to a layer of œdematous tissue around its base. It is more pronounced where connective tissue is most abundant, as at the frenum and behind the glans. Where the induration presents the sensation as if a leaf of parchment were placed beneath the ulcer, the thickening is known as *parchment induration*. It is sometimes described as split-pea induration, the feeling being that of a half of a pea, flat side up, slipped under the skin, or, in the Hunterian variety, it may be still more pronounced, and surround the sore. The induration is not fully developed for ten days or two weeks after the first appearance of the chancre, and lasts generally into the secondary stage.

Chancre is usually single, multiple chancre being due to simultaneous inoculation in several places, and not to auto-inoculation.

Histologically, a chancre consists of an infiltration of round cells, with some giant and epithelioid cells. There are marked periarteritis and endarteritis, the walls of the blood-vessels and the perivascular lymph-spaces sharing in the process. The cells are poorly nourished, and show a tendency to degeneration. Chancres are of variable duration, some lasting but a short time, and perhaps disappearing unnoticed—this is especially the case in women—while others last well into the secondary period. They may become phagedenic from the action of the same causes as in chancroid —namely, debility, intemperance, etc. Chancres in moist situations are in the secondary period liable to become converted into mucous patches. **Mixed chancre** is the result of a mixed infection with chancroid and syphilis in the same spot. Chancroid develops, runs its course, and may or may not be healed by the end of three weeks, when the chancre develops, and induration specific in character begins to appear, followed by constitutional syphilis. Re-ulceration of the scar and return of induration are not uncommon later in the constitutional stage, and may be mistaken for a fresh chancre.

Syphilitic Bubo.—During the course of chancre, about the time of development of induration, the inguinal glands on one or both sides undergo a moderate enlargement. Several glands may be involved, one being usually larger than the rest. The enlargement is painless, chronic, with a feel like that of the indurated sore, and suppurates only in cases of septic infection of the chancre. In extragenital chancres the buboes appear in the glands draining the region in which they originate, as the epitrochlear and the axillary in case of the finger, the submaxillary in case of the lip, and the inguinal in case of the rectum and the lower portion of the abdomen. The lymphatics themselves can sometimes be felt beneath the skin as hard painless cords. During the primary stage of syphilis the manifestations of the disease are purely local. After the appearance of the chancre there is a period of quiescence, lasting in the average case a little over six weeks (forty-five days), known as the period of *secondary incubation*, during which time the virus (bacterial or otherwise) is probably actively at work in the tissues, and at the end of this time the secondary constitutional symptoms appear.

Secondary Syphilis.—The lesions of the secondary stage consist mainly of pathological manifestations in the skin, the mucous membranes, the blood, the lymph-glands, the eye, and some of the internal viscera. Fever is often present as the first constitutional symptom before the eruption appears. From its preceding the eruption it is called *eruptive fever*, and may in some cases precede each fresh crop of skin-lesions. It is higher in the evening, is accompanied by malaise and by osteocopic pains, and after a few days disappears with the appearance of the rash.

The lesions of the skin and mucous membranes are the most prominent symptoms of the secondary stage. They are very important from a diagnostic stand-point, both as to the existence of the disease and the different stages of its progress. The eruptions simulate non-specific skin affections, and include roseola, papules, pustules, tubercles, and sometimes vesicles and bullæ; the latter are not uncommon in congenital but are very rare in

acquired syphilis. The lesions are due to hyperæmia and round-cell infiltration, are superficial in the early eruptions, taking place in the papillary and Malpighian layers, and in the later stages in the deeper layers of the derm. The eruptions are chronic, developing slowly and lasting a considerable time. They develop in successive crops, one coming before the preceding one has disappeared, so that the eruption is often polymorphous from the different manifestations being present simultaneously. They are generally symmetrical in the secondary stages, non-inflammatory, and therefore usually unaccompanied by itching. Their color is at first like that of raw ham, becoming copper-colored as they grow older, and leaving a characteristic brown pigmentation of the skin, due to a deposit of blood-pigment. The infiltrated cells never organize, but are absorbed or break down and ulcerate. Disappearance without ulceration and scarring is the rule with the early secondary eruptions, while those in the late secondary and tertiary stages may disappear, but often ulcerate, leaving white, shining cicatrices. Ulcerating lesions show thick black or brown laminated crusts, easily detached. Secondary eruptions are generalized and contagious, while tertiary manifestations show a tendency to localization, are not symmetrical, and are generally non-contagious. The secondary skin eruptions are roseola, papular, pustular, vesicular, and squamous. The ulcerating pustular forms, as impetigo rodens, ecthyma, and rupia, are really on the border-line between the secondary and tertiary lesions, partaking of some of the characters of each. **Rupia**, which is peculiar to syphilis, classified by some as a late secondary and by others as a tertiary phenomenon, starts as a pustule or a bulla, which ulcerates, the secretion drying into a crust, which by the addition of succeeding layers of secretion from the ulcer beneath forms a typical blackish-brown, cone-shaped crust, seated on an ulcerated base.

The mucous membranes are very frequently affected in secondary syphilis. The **sore throat** accompanying the earliest eruption is due to erythema, perhaps in company with mucous patches and ulcerations. The **mucous patch** is peculiar to syphilis, and occurs around the natural orifices and on the skin in situations where it is moist and warm, as under the breasts and on the scrotum. It is due to a modification of the eruption from the nature of the habitat, and histologically consists of an infiltration of round cells into the deeper layers of the epiderm, with in some instances hypertrophy of the papillæ and secondary changes in the epithelium, as thickening and ulceration. Clinically it is a small round or oblong patch of rosy color, generally elevated and covered with a whitish pellicle composed of fibrin and small round cells. The secretion is contagious, and is often the source whence infection is derived. The chancre is sometimes transformed directly into a mucous patch in the secondary stage. Superficial and deep ulcerations may occur in the secondary stage on the fauces, the palate, the tonsil, and the tongue. **Scaly patches**, smooth, white, shining spots, covered by adherent scales, are especially common on the inside of the cheek and on the tongue in smokers. They are found late in the secondary and in the tertiary stage. **Alopecia** is very common in the secondary stage, affecting the hair, eyebrows, beard, etc., but is not per-

manent. It may be due to lowering of the general tone of the system by the syphilitic virus, the nutrition of the hair-follicles being affected *pari passu* (as happens also in fevers), or to a localization of the eruption on the scalp, causing a partial baldness. Deep ulcerating tertiary lesions of the scalp cause permanent baldness.

With the development of the secondary stage there occurs a generalized glandular enlargement of the painless sluggish type observed in the primary bubo. **Glandular enlargement** is of much value from a diagnostic stand-point, the glands most easily examined being the post-cervical group, the axillary, and the epitrochlear gland lying just above the internal condyle of the humerus. The enlargement of the glands appears a little before the eruption, and disappears to a certain extent with the other active symptoms, but in many cases induration persists for a long time.

Analgesia, localized and general, is found in early secondary syphilis, being especially common in females. **Pain** in the bones, especially at night, and also provoked by pressure, and perhaps accompanied by nodular swellings, may be observed in the secondary stage. General rheumatoid pains are complained of at night. Other secondary symptoms are jaundice, occurring without structural hepatic changes, and nephritis, which, while less common than in the tertiary stage, may be manifested by albuminuria and dropsy, often responding promptly to antisyphilitic treatment. **Iritis** is the most frequent eye-lesion in the secondary stage. Choroiditis and retinitis occur much less frequently. Conjunctivitis is sometimes present, and rarely keratitis, which is a very frequent symptom in the inherited disease.

In addition to the above symptoms, there is a condition of **syphilitic cachexia**, in which the general vitality of the individual is reduced, and he becomes thin, pale, and weak. An examination of the blood shows, even in the period of secondary incubation, a decrease in the amount of hæmoglobin and in the number of red blood-cells, with a marked increase in the number of white cells. This becomes more marked before and during the eruptive period. Under the judicious use of mercury this anæmia disappears. Tertiary anæmia may develop, but is not proportionately so frequent. Secondary syphilis lasts from one to three years. Tertiary syphilis may develop at the end of a year, or may be deferred for ten or fifteen years. In the large majority of well-treated cases the disease is cured in the secondary stage.

Tertiary syphilis is irregular both in its onset and in its progress. It comes on generally in the third or fourth year. The lesions are chronic and sluggish. The surface lesions are unsymmetrical and irregular, and involve the whole thickness of the skin and mucous membrane, as well as the subcutaneous and submucous tissues. Internally there are gummata in the various organs, vascular changes, and sclerosis in the nervous system and elsewhere. The skin, nervous system, bones, mucous membranes, and viscera are attacked in about this order of frequency. The lesions are generally non-contagious. The characteristic affections of the skin are the tubercle and the gumma. The **tubercle** is a circumscribed, nodular infil-

tration in the skin, not extending into the subcutaneous tissue; it shows a tendency to be circinate in distribution, and is dry or ulcerative. On the face the ulcerative form is common, and may destroy large portions of the nose and lips, owing to its progressive nature and occasional phagedenic properties. A **gumma** consists of a mass of round cells, with giant and epithelioid cells, intermingled with a circumscribing layer of condensed connective tissue. There is also some new blood-vessel formation, but in the centre there is a tendency to myxomatous, fatty, or caseous degeneration. The *gumma* starts as a firm nodule beneath, and at first unattached to, the skin, single or multiple, and with a tendency to soften and discharge through the ulcerated overlying skin, the gummatous ulcer remaining as an indolent, circumscribed, circular sore, with thickened edges, leaving after cicatrization a smooth, white, depressed scar. It is especially liable to become serpiginous on the abdomen. **Osseous and joint lesions** occur both in the secondary and in the tertiary stage, more commonly in the latter. (See pages 538, 603.) **Dactylitis** is quite common in the hereditary form, and is rare in acquired syphilis, existing in two forms, either (1) starting from the subcutaneous and fibrous tissues of the joints, or (2) involving the bone and periosteum primarily. Syphilis of the **testicle** causes a hard, smooth, painless enlargement of the whole organ, which rarely ulcerates. Exceptionally localized gummata can be made out, but, as a rule, the general shape and outline are preserved. If arrested by early treatment the function of the organ is preserved. Among the syphilitic affections of the **nervous system** are meningitis, epilepsy, paraplegia, hemiplegia (following rupture of diseased blood-vessels), and gummata of the brain and cord. The nerve-structures themselves are probably not affected primarily by syphilis, their involvement being secondary to connective-tissue and blood-vessel changes.

Inherited Syphilis.—Syphilis in the secondary stage is very frequently transmitted to the offspring. Tertiary syphilis is not generally transmissible. For syphilis to be transmitted it is probably necessary that the mother should be infected—that is, the father cannot transmit syphilis, the mother remaining healthy; this is denied by Kassowitz and others, including Taylor. That the mother is syphilitic is rendered more probable by the fact that she cannot contract the disease from her syphilitic child (Colles's law), although she herself may seem perfectly free from the disease. If a healthy woman acquires syphilis during pregnancy her child may inherit the disease, especially if infection takes place before the sixth month, as pointed out by Ricord. Later than this the child usually escapes, although in Chabalier's case the child contracted it during the eighth month. Abortions are very frequent in syphilitic women, occurring about the sixth month, associated with disease of the placenta and the expulsion of a macerated fœtus showing visceral lesions and perhaps pemphigus of the hands and feet. After several abortions the woman may give birth to a living child, which usually shows no signs of disease until the third week, although in some cases the eruption is present from the first. The infant then shows signs of malnutrition, becomes thin and wizened, and presents a prematurely old appearance. The early eruptions are superficial and gen-

eralized, and are associated with visceral disease, especially of the liver and lungs, the kidney, spleen, nervous system, and testicle being sometimes diseased. The eruptions comprise roseola, papules, pustules, tubercles, and bullæ (pemphigus).

Syphilitic pemphigus, rare in the acquired form, may be present at birth or appear soon after. Authorities agree that it indicates a very malignant form of the disease. It consists of bullæ which become pustular and ulcerate, the usual location being on the palms of the hands and the soles of the feet. Mucous patches are also present. With the earliest eruptions there is an inflammation confined at first to the nasal mucous membrane, producing the characteristic *snuffles*, which later, by ulceration and destruction of bone and cartilage, produces the sunken nose of hereditary syphilis. (Fig. 824.) Ulcerations are present around the mouth and the anus, which leave linear scars, *rhagades*, on healing. The bone-lesions consist of epiphyseal and other changes. At the epiphyses there is an osteochondritis resulting in premature attempts at ossification and sometimes separation of the epiphysis, abscess, and caries. Periostitis of the long and flat bones results in the formation of osteophytes, which on the skull are grouped around the anterior fontanelle as four nodes separated by the sutures, the "natiform" appearance of Parrot. **Dactylitis** is quite common.

Fig. 824.

Facies of hereditary syphilis.

The prognosis is bad, death supervening in seventy per cent. of these cases. The later the disease appears the better is the prognosis. If the child survives, the late lesions become milder in nature. **Interstitial keratitis** is a not uncommon and a very typical symptom. **Iritis, choroiditis,** and **retinitis** may also be present. A peculiar condition of the incisor teeth, first described by Jonathan Hutchinson, is of diagnostic value in connection with other signs of inherited syphilis. (Fig. 825.) Dr. Harrison Allen has called attention to the fact that a similar deformity of the teeth may result from other diseases affecting children during the period of their development, and all observers are aware of the fact that many cases presenting other marked symptoms of inherited syphilis often have well-developed teeth. The central upper incisors of the permanent set are those involved, the deformity consisting in a pegging due to a narrowing of the cutting edge, associated with a central notch on the free border. There is often deafness, due to otorrhœa. The nervous system is sometimes involved. The subject of hereditary syphilis very rarely contracts the disease in later life, and there are few, if any, authentic cases of transmission to the third generation. By Profeta's immunity is meant the immunity shown by children of syphilitic parents to syphilis, even if they themselves seem healthy.

Treatment.—The treatment of syphilis should be both hygienic and medicinal. Every means must be taken to keep the patient in good physi-

cal condition by healthful surroundings, good food, and an avoidance of physical and mental overwork, thus allowing nature to assist in overcoming the disease. Alcohol, especially in excess, is injurious, and, although light beverages may sometimes be allowed, the use of strong wines and liquors should be interdicted. Tobacco often excites and assists in keeping up mouth and throat symptoms, and its use should therefore be forbidden. The skin must be kept in good condition, and attention should be paid to the teeth. During the primary stage, in addition to the hygienic treatment above described, local treatment directed to the chancre should be employed. **Excision** of the chancre has been practised in all its stages, in the hope of aborting syphilis, but without success. The sore should be kept clean by the use of mild antiseptic lotions, and dusted with iodoform, aristol, calomel, or acetanilid, iodoform being the best. If complicated by chancroid, the *mixed chancre* should be cauterized, if necessary, as directed in treating chancroid. Phagedenic ulceration requires the same treatment as directed for chancroid, and in addition is sometimes benefited by the internal administration of mercury. For the primary adenitis a spica bandage may be worn and mercurial ointment rubbed in locally to aid resolution. If suppuration occurs as a result of pyogenic infection, it must be treated as a suppurating bubo. It is seldom advisable to administer mercury during the primary stage. An absolute diagnosis of syphilis cannot always be made from the appearance of the primary sore, and hence, if mercury be administered in this stage, a state of uncertainty often remains in the minds of physician and patient. Again, if mercury be administered before the secondary stage, while it may postpone the appearance of the eruption and alter the natural sequence of symptoms, it does not abort the disease.

Fig. 825.

Hutchinson's teeth with rhagades of the lips. (Museum of the German Hospital of Philadelphia.)

After the onset of the secondary stage, as manifested by the appearance of the rash, the question of medication becomes of primary importance. The drugs of peculiar antisyphilitic value are mercury and iodide of potassium. Mercury is of value in all stages of syphilis, iodide of potassium especially in the late secondary and tertiary periods. Mercury may be administered by the mouth, by inunction, by fumigation, and hypodermically, the aim being not to salivate the patient, but to keep him sufficiently under the influence of the drug to overcome the syphilitic virus, for which it is almost, if not quite, a specific. The combination with the iodide in the form of the *mixed treatment* is of especial value in the late secondary and tertiary stages. The preparations of mercury suitable for internal use are the protiodide, the bichloride, calomel, gray powder, and blue pill. The

protiodide is a favorite preparation, and is that preferred by Keyes in what he calls his **tonic treatment** of syphilis, which consists in starting with a small dose (one-sixth of a grain of the protiodide) three times a day, and gradually increasing the quantity until tenderness of the teeth and gums, or diarrhœa, shows that a marked constitutional effect is produced. The quantity necessary to do this is called the *full dose;* the half of this is the *tonic dose*, and is to be administered steadily for many months; the difference between it and the full dose is called the *reserve dose*, and is added to the regular quantity when indicated by a fresh outbreak of syphilitic lesions. Keyes asserts that under this method of administering mercury the number of red blood-corpuscles is increased, the general health improved, and the disease often cured in the secondary stage. Other writers consider such a course entirely too mild, and are guided in their dose by the effect produced on the rash and other symptoms, increasing the quantity until its effect is shown by the disappearance of the eruption and glandular enlargements, and the improvement in the patient's general health, keeping the quantity below the point necessary to salivate or cause gastro-enteric symptoms. The combination of opium with the mercury will often enable the patient to increase his dose beyond that otherwise possible. When the necessity of vigorously attacking syphilitic lesions demands it, **inunctions** are a very efficacious means of treatment, and may be used as a routine or in combination with internal treatment, when it is desired rapidly to impress the system or to attack a generalized eruption. It is often a useful plan to institute a short course of inunctions after several months of internal medication. Mercurial ointment is the best preparation, from ʒss to ʒi being rubbed in daily in different parts of the body in succession, in combination with hot baths, to favor absorption. The great inconveniences of the method are its dirtiness and the difficulty in following it out with secrecy at the patient's home. **Fumigation** is practised by introducing the fumes of mercury, obtained by heating calomel or cinnabar over a lamp, mixed with steam, under a frame covered with blankets, or other device, in which the patient, stripped of his clothing, is seated, his head remaining outside. After an exposure of twenty or thirty minutes to the fumes, the patient either goes to bed or wraps up, to avoid rapid cooling of the surface, at the same time avoiding rubbing off the coating of mercury deposited on the skin. This method is useful as an adjunct to other modes of treatment, and will often hasten the disappearance of an obstinate or generalized rash.

Hypodermic injections of calomel, gray oil, yellow oxide of mercury, corrosive sublimate, and other preparations of mercury have within the last few years attained much popularity in the treatment of syphilis, and extravagant claims have been made as to the ease and rapidity of cure by this method. The injections are made into the subcutaneous tissue, and even the muscles, the back and buttocks being favorite sites, but, while often effective, are painful, and, especially when using the insoluble preparations, as calomel, are liable to be followed by abscesses at the sites of the injections. When a rapid effect is necessary, as in syphilis of the brain, spinal cord, and eye, and when the stomach is rebellious, and other means, as inunctions

and fumigations, are impracticable, hypodermic medication should be employed. The insoluble preparations are given suspended in some medium like glycerin or liquid vaseline. Calomel may be given in one-grain doses, repeated every week or two, and bichloride of mercury in one-sixth to one-tenth grain doses every day or every other day. Scrupulous attention must be paid to asepsis in preparing and giving the injection, and a careful watch kept for signs of salivation.

Late in the secondary stage, or earlier in those cases of precocious syphilis which are marked by the early appearance of gummata and nervous syphilis, iodide of potassium or iodide of sodium becomes of use, and in the tertiary stage is of great benefit both alone and in combination with mercury. Starting with ten-grain doses, it may be pushed until one or two ounces a day are being taken, when the nervous or other symptoms demand it. Excessive, long-continued use of the iodides causes a condition known as iodism, in which the stomach is often much disturbed. The iodide may be given in plain water, wine of pepsin, Vichy water, or milk well diluted, two or three hours after eating. The combination of bichloride of mercury, iodide of potassium, and compound syrup of sarsaparilla is a popular one, as is also that of biniodide of mercury and potassium iodide. In hereditary syphilis, inunctions may be administered by smearing mercurial ointment on the binder, or calomel, gray powder, or bichloride of mercury may be prescribed internally. Later, the iodides are useful in combination with mercury and alone. If a syphilitic woman becomes pregnant, she should be kept under medication, in the endeavor to secure a healthy child. Similarly, if a pregnant woman acquires syphilis, she should be thoroughly treated, and if the diagnosis be clear from the appearance of the chancre it will be better to begin treatment at once, without waiting for the secondaries to appear.

Local Treatment of Secondary and Tertiary Eruptions.—The advantage of treating generalized eruptions by fumigations and inunctions in combination with internal medication has already been emphasized. Localized secondary and tertiary eruptions should be treated locally with mercurial ointment, ammoniate of mercury ointment, oleate of mercury, etc. A solution of bichloride of mercury from two to four grains to the ounce may be painted on with advantage. Ulcerating lesions demand removal of crusts and stimulating applications, as iodoform, black wash, or dilute ointment of nitrate of mercury, the iodoform being especially happy in its results. In the treatment of serpiginous ulcers the following ointment, ungt. hydrarg., ʒiij ; ac. salicylici, gr. xij ; ungt. adhesivi, ʒiv, spread upon kid and applied to the surface of the ulcer and the surrounding indurated tissues, will be found most satisfactory. The dressing should be renewed at intervals of twenty-four or forty-eight hours. Mucous patches on the skin should be kept clean, stimulated, and dusted with iodoform, calomel, or other powder. When present in the mouth, an antiseptic gargle may be prescribed, and the ulcers themselves touched with acid nitrate of mercury, pure or diluted, nitrate of silver, sulphate of copper, or a solution of chromic acid, gr. x, to water, ℥i.

CHANCROID, OR SIMPLE VENEREAL ULCER.

Chancroid, or soft chancre, as it is sometimes called, is an ulcer commonly found on the genitalia, contagious in nature, and generally of venereal origin. Unlike chancre, the primary lesion of syphilis, with which up to comparatively recent times it was confused, it is a local affection, never being followed by constitutional symptoms. Its exact cause has not yet been fully demonstrated. It is considered by some authors to be a specific lesion caused by a special bacterium, and a streptobacillus has been described by Ducrey and Unna as occurring in the pus and tissues of the ulcer, which they believe to be the cause of the affection. Other investigators regard it as non-specific, and assert that it can arise as the result of irritation, uncleanliness, and pus-infection acting on simple lesions, causing them to take on the peculiar features of chancroid. (Bumstead, Finger, Taylor.) It has been successfully inoculated in the lower animals.

Chancroid is most frequently observed among the lower classes, and is, therefore, more frequently encountered in hospital than in private practice, in which latter chancre is the more common lesion. The most common seat of the ulcer is at the side of the frenum and in the sulcus behind the glans; it is also found on the inner and outer layers of the prepuce, on the glans, around the meatus, and on the penis above the prepuce, and by auto-inoculation on the scrotum and thighs, and is sometimes encountered in the urethra. In women it affects the labia, fourchette, clitoris, vestibule, rarely the vagina itself, and the os uteri. The discharge running down over the perineum inoculates that region and the anus, the latter situation in the male being generally inoculated in the practice of sodomy. Chancroid has no period of incubation. As soon as the germs penetrate the epithelial layer, or immediately in those cases in which infection takes place through an existing abrasion, the inflammatory process begins, and by the second or third day the part becomes the seat of a pustule surrounded by an inflammatory area. The pustule soon breaks down, producing the typical chancroidal ulcer. The lesion is often unnoticed until the ulcerative stage is reached.

The appearance of the chancroidal ulcer is characteristic. It is round, oval, or of irregular shape, with a punched-out appearance, due to the sharply cut or undermined edges, in marked contrast to the sloping edges and floor of a chancre. The floor is covered with a grayish-yellow deposit of membrane, beneath which is the uneven surface of the ulcer. (Plate IV., Fig. 4.) There is a thin, brownish, unhealthy pus secreted, which is freely auto-inoculable—that is, capable of producing exactly identical lesions on the same individual wherever inoculated. There are multiple ulcers as a result of this property in a majority of cases. On compressing the base of the sore between the fingers there is an absence of the characteristic circumscribed induration of the chancre, but there may be a diffuse inflammatory œdema. The ulceration is progressive, especially on the mucous membranes, and may involve considerable destruction of tissue. There is usually some pain felt in cases of chancroid, and it may be very severe in rapidly advancing and phagedenic cases, which is in contrast to the painless

chancre. In untreated cases the advancing stage lasts for a week or two, being succeeded by a stationary period of the same duration, after which the process of healing begins, being marked by a change in the character of the secretion, which becomes more healthy, and by the disappearance of the pseudo-membrane and the springing up of granulations. The edges lose their punched-out appearance and become the starting-points for cicatrization. At any stage the ulcer may lapse into its former virulent condition.

Complications.—**Phagedena** is the most serious complication of chancroid, to which, however, it is not confined, being observed also in the course of chancre. It consists in a marked increase in the tissue-destroying properties of the ulcer. It is predisposed to by factors lessening the resistance of the tissues, as unsanitary surroundings with a lowered condition of strength, due to alcoholic excesses, scurvy, diabetes, etc., and often in conjunction with local irritation and uncleanliness.

Phagedena is of two kinds—*gangrenous*, or sloughing, and *serpiginous*. In the first variety the ulcer becomes the seat of a gangrenous process, indicated by swelling, pain, a scanty sanious discharge, a dusky color of the parts, and the rapid formation of a slough, involving the entire chancroidal surface and perhaps destroying the entire prepuce or glans. In the serpiginous variety the ulcer extends rapidly or slowly, destroying the tissues in its course, perhaps denuding the penis and exposing the testes in its ravages. There is marked constitutional involvement. In the chronic serpiginous variety, which most frequently has its origin in a chancroidal bubo, the process lasts for months or even years, the ulcer healing at parts as the ulceration advances over the abdomen or down the thigh. It may cause death by exhaustion, or by peritonitis from perforation of the abdominal wall.

Inflammatory phimosis is a frequent complication of chancroids situated beneath the prepuce, which, by retention of the discharge and interference with dressing, favors phagedena and bubo. The concealment of the lesion renders diagnosis difficult, especially from chancre and gonorrhœa. The history of the case, the acuteness of the inflammation, and the character of the discharge are points of most importance in the diagnosis.

Paraphimosis may be the result of the same inflammatory condition of the prepuce. **Lymphangitis** appears as hard, red, knotty cords under the skin of the penis, painful, and sometimes associated with redness and œdema of the whole organ. **Abscess** may develop, followed by a secondary chancroid, which develops at its site.

Bubo.—This is the most common complication of chancroid, its frequency being variously estimated at from ten to thirty per cent. It is more frequently encountered in hospital than in private practice. It may develop at any stage of the disease, and has been known to appear after healing of the sore had taken place. It is favored by improper treatment, irritation, and neglect of cleanliness. It commonly appears in the groin on the side corresponding to the ulcer, the process being carried to the inguinal glands by the lymphatics of that side, but if the sore is at the frenum, where the lymphatics cross, it may occur on both sides. Chancroids

at the frenum are peculiarly apt to be complicated by bubo, from the richness of the lymphatic supply in this locality. The glands affected are those along the line of Poupart's ligament. The resulting bubo is usually classified as simple or virulent (chancroidal), the former being identical with that complicating gonorrhœa or an ordinary infected wound and not necessarily going on to suppuration, while the latter is allied in virulency to the chancroid causing it, and develops after opening into a secondary chancroid. It is claimed, however, by Strauss that the pus of even the virulent bubo is free from micro-organisms before opening, and that the development of chancroidal properties is due to secondary infection. This may be true in many cases, but chancroidal bubo is more rapid in its course and more severe in its symptoms than other forms. One or more glands may be affected, the swelling being inflammatory instead of the painless swelling of the polyganglionic bubo of syphilis, and in the case of virulent bubo rapidly goes on to suppuration, the abscess-cavity after opening being lined with a gray slough and presenting irregular edges, with, in some cases (whether as a result of secondary inoculation or not), an auto-inoculable secretion. In strumous subjects there is a tendency to an indolent inflammation of a number of glands, forming a large swelling, perhaps suppurating, and resulting in the formation of numerous fistulæ, with periglandular suppuration and a long-standing discharge. Chancroidal bubo, as already mentioned, may be a starting-point for serpiginous ulceration.

Diagnosis.—Chancroid must be separated from other ulcers found on the genitalia, those with which it is most likely to be confused being the chancre, herpetic ulceration, ulcerative balanitis, and mucous patches. From *chancre* it may be differentiated by the rapid onset after exposure, the punched-out appearance of the ulcers, which are usually multiple, the auto-inoculable secretion, the absence of cartilaginous induration, and the non-development of constitutional symptoms. *Herpetic ulceration* may be an idiopathic process, or, like *balanitis*, result from irritation and uncleanliness, the lesions being shallow and irregular, not auto-inoculable or destructive, and not apt to be complicated by bubo. *Mucous patches* do not have the characteristic appearance of chancroid, and are associated with signs of general syphilis. In any case of doubt as to the diagnosis of chancroid, auto-inoculation will be the crucial test.

Treatment.—In the ordinary case of chancroid, the first thing to be considered is the question of converting it into a simple ulcer, thus destroying its power of auto-inoculation and lessening the chances of bubo. It was formerly the universal practice to cauterize chancroids freely, but at present the results following the antiseptic treatment of such sores have been so satisfactory that destructive cauterization is reserved for special cases. In well-to-do patients who are careful as to cleanliness, unless phagedena occurs, cauterization is seldom required, while in dispensary practice it is often safer to employ it, as these patients are careless as regards the care of the sore. Cleansing of the ulcers with peroxide of hydrogen, and their daily irrigation with a 1 to 500 or 1 to 1000 bichloride solution, followed by the application of powdered iodoform, aristol, iodol, or acetanilid, or the use of an ointment of iodoform or aristol, ʒi ; ungt. petrolat.,

℥i, will usually be followed by satisfactory healing of the ulcers. If wet dressings are preferred, the ulcers may be dressed with lint saturated in 1 to 60 carbolic solution, or 1 to 5000 bichloride solution, or in a solution of calomel, gr. x ; lime water, ℥i.

Chancroid of the meatus or in the urethra itself should not be cauterized, and healing chancroids, of course, do not require it. Very much inflamed chancroids demand elevation and rest of the part, with the local use of lead water and laudanum. Where the surfaces affected are in contact, as under the prepuce, and on the labia in women, they must be kept separated by lint or cotton covered with an ointment of iodoform or aristol. Cauterization with nitric acid or the actual cautery is reserved for cases in which the ulcers increase in size and depth in spite of the former treatment, or in which phagedena develops ; here, after drying the surface of the ulcer with absorbent cotton, it may be covered for a few minutes with cotton saturated with a four per cent. solution of cocaine, and after removing this the surface should be freely cauterized with nitric acid or with the actual cautery ; the latter agent is the most satisfactory, but is so alarming to the patient that it cannot often be employed unless an anæsthetic is administered. After cauterization, some of the antiseptic dressings previously mentioned should be employed. Chancroids beneath the prepuce, if cauterized, are liable to be attended with much œdema : hence after the application the patient should be kept at rest, if possible, and measures taken to avoid inflammatory phimosis.

Inflammatory Phimosis.—This complication is treated by rest and elevation of the penis, with the external application of lead water and laudanum, and syringing with antiseptics and astringents should be tried. If these fail and there is any doubt as to the extent of the lesion, or if there are signs of threatening gangrene, it is better to slit up the prepuce by a dorsal incision and thoroughly expose the sore. A formal circumcision is generally inadvisable, owing to the liability to infection of the edges of the wound with chancroidal matter, but if the lesion be situated on the margin of the prepuce a V-shaped piece may be excised with advantage. Chancroid of the meatus demands irrigation and an iodoform dressing, and the same measures are useful in case the urethra is infected higher up.

Phagedena in any form demands careful attention to the health, tonics and stimulants being used, and opium freely administered to relieve pain. Potassio-tartrate of iron in twenty-grain doses is recommended by Ricord. Locally, thorough curetting, followed by cauterization and the use of iodoform, and every means to encourage granulation, must be used. Any reappearance of the process demands a repetition of the same treatment. If, owing to the patient's condition or the proximity of important structures, as large vessels, the above treatment is inadvisable, the prolonged application of hot water by intermittent or continuous baths, local or general, is of the greatest value, as is spraying of the lesion with hot antiseptic solutions.

Bubo.—In the early stage of bubo, rest, pressure, and some form of counter-irritation should be employed. A blister may be applied, or leeches, if the case be seen early, or tincture of iodine may be painted over the surrounding region. If the patient is forced to be about, the application to

the part of mercury and belladonna ointment on lint, with a well-fitting spica bandage, will be of service. As a means of aborting bubo M. K. Taylor recommends the injection into the gland of from ten to forty minims of a 1 to 60 solution of carbolic acid, and Welander uses benzoate of mercury, 1.00; sodium chloride, 0.3; and distilled water, 100, for the same purpose. If suppuration occurs, the pus may be evacuated, and the abscess-cavity irrigated, dusted with iodoform, and packed loosely with iodoform gauze. If any enlarged glands not yet broken down are found in the cavity, they must be dissected out, as they are involved in the suppurative process. Care must be exercised in removing those deeply seated to avoid injuring the femoral vessels, to which they may have become adherent through inflammation. If the abscess-cavity becomes transformed into a chancroidal ulcer, it will demand the treatment applicable for chancroid, possibly including cauterization. Chronically enlarged glands that do not yield to milder treatment will demand extirpation, as well as those constituting the strumous bubo found in scrofulous cases and complicated by sinuses and prolonged suppuration. The treatment for serpiginous ulceration has already been described. Lymphangitis requires rest, elevation of the penis, and sedative applications. Abscesses should be opened, and when developing into chancroidal ulcers should be treated as if they were primary sores.

GONORRHŒA.

Gonorrhœa is an inflammation most commonly found attacking the mucous membrane of the genitalia, but is occasionally present in the mucous membrane of other portions of the body, as the rectum, the conjunctiva, and, rarely, the mouth. True specific gonorrhœa is due to a micro-organism called the *gonococcus of Neisser*. (Plate I., Fig. 4.) This bacterium, which is found in the discharge, is a kidney-shaped coccus, commonly arranged in pairs, with the flattened edges separated by a narrow interval, and generally an inhabitant of the pus-cells or attached to epithelial cells, a few being observed free. It is stained by the aqueous aniline dyes, but is decolorized by Gram's method. A watery solution of gentian violet is most convenient for its detection. There are other organisms found in the normal and inflamed urethra which may be mistaken for the gonococcus, among them the so-called pseudo-gonococcus, which must be remembered as possible sources of error. Urethritis is also sometimes excited by causes other than the gonococcus, as by violent prolonged coitus, especially in combination with alcoholic stimulation and the presence in the woman of an acrid leucorrhœal or menstrual discharge; by the use of instruments; by the passage of a calculus; by masturbation; by certain drugs taken internally, as cantharides, and by strong injections. The staphylococcus, streptococcus, and bacillus coli communis have been noted as causative agents in the production of urethritis. Urethral discharges are sometimes present in syphilis from the existence of chancre or mucous patches in the urethra, and may also occur as a result of tubercular ulceration. As predisposing causes of gonorrhœa may be mentioned phimosis, a large meatus, hypospadias, and urethral lesions from previous attacks, such as chronic thickenings and ulcerations. Prolonged copulation and alcoholic excess are factors, by ex-

citing irritation and thus rendering the tissues less resistant to invasion. The presence of the gonococcus in inflammatory discharges in cases where no specific infection can be found in the other partner in the sexual act has led certain observers, as Taylor, to suggest that the gonococcus may be an inhabitant of the normal urethra which is capable under favoring circumstances of becoming virulent. The possibility of error should act as a warning against the too hasty expression of an opinion as to the specific nature of any case.

Pathology.—The infection of the urethra occurs almost invariably during the sexual act, although mediate contagion, in which towels, etc., act as carriers of infection, is, of course, possible. The gonococcus having gained admission to the urethra, there elapses a period of incubation varying from two to fourteen days, the majority of cases developing in the first week. In very susceptible persons, especially those with lesions of the urethra remaining uncured from previous attacks, symptoms may show themselves within forty-eight hours. *Non-specific urethritis* has no true period of incubation, and may come on in the course of a few hours.

During the incubation stage the gonococci are multiplying and penetrating between the epithelial cells, beginning at the fossa navicularis and travelling backward. The diplococcus finds its way between the epithelial cells to the superficial layers of the subepithelial connective tissue, where it excites a violent inflammatory reaction, consisting in the migration of leucocytes and serum from the dilated capillaries and a lifting up and exfoliation of the epithelium. In the subepithelial tissue the process of bacterial growth goes on attended by round-cell infiltration and bacterial invasion of the pus-cells coincident with the purulent stage of the disease. The process of elimination and repair takes place by a conversion of the epithelium from a columnar to a squamous type, which the gonococci cannot penetrate.

Symptoms.—The first symptom noticed at the end of the period of incubation is a slight tickling or itching sensation referred to, or immediately behind, the meatus, with a little burning during or after urination, accompanied by a slight mucous discharge, perhaps gluing the lips of the meatus together. The lips of the meatus soon swell, becoming slightly reddened, and often everted. The discharge increases, and, while at first consisting of epithelial cells with gonococci attached and a few pus-cells, soon becomes milky, and after a few days decidedly purulent and thick yellow or yellowish green. (Plate IV., Fig. 5.) The disease reaches its height from the seventh to the tenth day. There is then profuse discharge, *ardor urinæ*, or burning in urination, the glans is reddened, sometimes swollen, and œdema of the prepuce, with consequent phimosis or paraphimosis, is not uncommon. The whole organ may become swollen, and, as the disease spreads backward along the urethra, the corpus spongiosum becomes involved by extension, and is painful and tender. With the ardor urinæ there is a change in the size and shape of the stream, from the swelling of the mucous membrane making it smaller, and often twisted or forked, simulating stricture. Retention of urine may follow implication of the prostate. There is generally increased sexual feeling, and frequent

seminal emissions are not uncommon. **Chordee** is a very distressing symptom, and is due to an extension of the inflammatory process to the meshes of the corpus spongiosum. Erection coming on, the corpus spongiosum can take part only imperfectly in the process, and the organ assumes a bent or twisted shape, severe pain being produced by the stretching of the inflamed tissues. Chordee occurs especially at night after the patient is warm in bed, and may cause great suffering and loss of sleep.

These inflammatory symptoms remain at their height from one to three weeks, at the end of which time they gradually disappear, the pain ceasing, the sexual symptoms abating, and the discharge becoming thin and milky, then watery, and ceasing after lingering as a mucous drop, which can be pressed out, or is noticed at the meatus especially in the morning. The disease may be prolonged much beyond its usual limits by violent exercise, the use of alcoholic beverages and stimulating foods, and sexual excitement of any kind. The average duration of a successfully treated case is from four to eight weeks. Constitutional symptoms are not common, although there may be slight depression and malaise or, rarely, slight fever.

It was formerly believed that the posterior urethra generally escaped, the inflammation being checked in its backward progress by the compressor urethræ muscle, but this has recently been shown to be incorrect. Infection probably takes place in from eighty to ninety per cent. of cases. The symptoms of **posterior urethritis** are a decrease in the amount of discharge, increased frequency of urination, and deep-seated burning pain in the perineum at the end of the act, sometimes also referred to the glans. Urination is often urgent and accompanied by tenesmus, being repeated every few minutes, and perhaps followed by the passage of blood from the inflamed mucous membrane, or there may be temporary retention. Constitutional symptoms are usually absent, but erections and seminal emissions follow irritation of the region around the orifices of the ejaculatory ducts, and extension to the seminal vesicles and epididymis is liable to occur. Thompson's two-glass test is a convenient method for the detection of posterior urethral inflammation. The pus from the posterior urethra has a tendency, when present in any amount, to flow back into the bladder. If the patient passes his urine into two glasses, that in the first will be cloudy from the pus washed out of the urethra, while cloudiness in the second, excluding bladder and kidney diseases, will indicate posterior urethral inflammation.

The first attack of gonorrhœa is the most severe, but is the one most likely to be followed by complete recovery. If instead of the discharge disappearing it becomes chronic, we have the condition known as chronic urethritis, or *gleet*, due to a variety of pathological changes, which will be described later.

Treatment.—The treatment of gonorrhœa embraces hygienic and medicinal measures. A patient presenting himself for treatment must be directed to abstain absolutely from alcoholic beverages. Sexual intercourse must be interdicted as well, as must all associations tending to sexual excitement. Physical exercise is to be restrained as far as possible, the nearest practicable approach to absolute rest being made. Plain diet, with avoid-

ance of highly seasoned food and with the use of plenty of water, should be directed; a milk diet is the best. A suspensory bandage should be worn, as it diminishes the risk of epididymitis. The patient must be cautioned as to the contagious nature of the discharge and as to the special attention necessary to the disposition of towels and dressings, to avoid infecting his own conjunctiva or that of other persons with whom he is brought in contact.

The surgeon should give instructions as to the application of dressings to receive the discharge. Some form of gonorrhœa-bag may be worn, or if the prepuce is long it may be retracted and a piece of lint or a little absorbent cotton be wrapped around the glans and retained by pulling forward the prepuce, or, if short, a piece of lint or muslin may be perforated for the penis and then dropped around the meatus. The dressings must not occlude the meatus or retain the secretion in immediate contact with the glans. If there is much ardor urinæ, it may be relieved by immersion of the penis in hot water during urination, and the immersion may be practised in any case two or three times a day, to relieve the congestion. Hot baths are also conducive to comfort, especially before retiring.

Many attempts have been made to discover a successful *abortive* treatment for gonorrhœa. Nitrate of silver in strong solution has had many advocates, but has proved disappointing and dangerous. It should be remembered that the use of strong astringent or antiseptic solutions used as means of aborting the disease may aggravate the condition and produce cystitis, prostatic congestion, abscess, or epididymitis. Any abortive treatment can be of service only during the first day or two, before the microorganisms have gained a foothold on the subepithelial surface. The method of anterior irrigation, which is useful in all stages of anterior urethritis, is probably the least objectionable. It may be practised by passing a catheter four or five inches into the urethra—that is, to the compressor urethræ muscle—and attaching to it a fountain syringe containing a weak solution of permanganate of potassium, bichloride of mercury, or nitrate of silver, with which the urethra should be irrigated two or three times a day, from one to two quarts of the solution being used. A hot solution of permanganate of potassium, beginning with 1 to 6000 and increasing to 1 to 2000, is the most satisfactory. Or the patient may be directed to use the same solution himself with an ordinary syringe, using a number of syringefuls three times a day.

Internally, an alkaline mixture is useful by rendering the urine less irritating and decreasing the ardor urinæ. Citrate of potassium alone, in ten-grain doses, or in combination with extractum hyoscyami fluidum (one to five minims), can be given three times a day, or powders of potassium bicarbonate and potassium citrate, each five grains, may be dissolved in a glass of water and taken every three hours during the day. Bicarbonate of sodium, in doses of ten grains every three hours, is useful for the same purpose. There are some drugs, such as copaiba, cubebs, and oil of sandal wood, which, acting during elimination by the urine, exert a curative influence on the urethral membrane. Some surgeons use these in the declining stages only, but others start them early and give increasing doses during

the acute stage. Balsam of copaiba, in from ten- to twenty-minim doses, in capsules, or in combination with an alkali, may be administered three times daily. It has a tendency at times to disorder the stomach, and its use may be followed by a copaiba rash on the skin. Sandal-wood oil is given in a similar manner and in the same dose. Cubebs, copaiba, or oil of sandal wood, in doses of from ten to twenty minims, may be administered in a capsule combined with salol five grains and pepsin two grains. The following mixture is recommended by Keyes: Potassii citratis, ʒij–ʒvi; bals. copaibæ, ʒiij–ʒvi; ext. hyoscyami fl., ʒss-ʒij; syr. acaciæ, ℥iss; aq. menth. pip., q. s. ad ℥iij. Sig.—A teaspoonful in water three times a day.

When chordee is present, the patient should take a hot bath before retiring, and sleep on his side on a hard bed with light covering. Bromide of potassium is a useful agent, and monobromide of camphor and lupulin may be employed with advantage. Opium with camphor in the following suppository, to be used at bedtime, is most useful: Pulv. opii, gr. i; pulv. camphoræ, gr. iij; ol. theobrom., q. s. When erection comes on, cold should be applied in some form. The patient should be warned against breaking the chordee, as this procedure is apt to result in traumatic stricture.

Injections.—During the incipient and acute stages of the disease injections are generally omitted, but if used should consist of mild antiseptic and sedative washes or irrigations by the method previously described, such as warm boric acid solution, gr. v to water f℥i, bichloride of mercury solution 1 to 20,000, permanganate of potassium 1 to 2000, a solution of sulphocarbolate of zinc gr. ½ to water f℥i, or peroxide of hydrogen diluted one-half or one-fourth.

In the later stage of the disease the treatment by injection becomes of great importance. The character of the discharge, which changes from a greenish yellow to a grayish white, must be watched, and furnishes the signal for treatment. Astringents are now of great value. Sulphate of zinc and sulphocarbolate of zinc (1 to 5 gr. to water ℥i), acetate of zinc (2 to 12 gr. to water ℥i), nitrate of silver 1 to 4000, and sulphate of copper (1 to 5 gr. to water ℥i), are the most generally applicable. The following formulæ will be found useful: Ac. carbolici, zinci sulphocarbolat., aluminis, āā gr. v; glycerini, f℥ss; aquæ, q. s. ad f℥iv. Or zinc. sulph., gr. xv; plumbi acetat., gr. xxx; tr. opii, fʒij; aquæ, q. s. ad f℥vi.

It is well to begin with the milder solutions, and if an injection causes pain it must be diluted. The patient should urinate before using it, so as to wash out the urethra and permit the full local action of the injection. The syringe should hold from two to three drachms, and the patient should be instructed in the method of using it. Sitting on the edge of a chair, or standing with the feet separated, holding the syringe in the right hand, the nozzle should be gently introduced and the meatus compressed laterally with the fingers of the left hand, so as to prevent escape of the fluid. The contents should be gently thrown in until the urethra is distended; the syringe is then withdrawn, and after one or two minutes the fluid is allowed to escape. The injections may be given three or four times daily.

Treatment of Posterior Urethritis.—When there is present a high grade of posterior urethritis, as shown by frequent and imperative urina-

tion, hæmaturia, and a diminution or cessation of the discharge, injections should be discontinued, and the patient put to bed and given a very light diet, consisting largely of milk. The bowels should be kept open by laxatives and the patient encouraged to drink freely of water. If antiblennorrhagics are being administered, they should be stopped and urinary sedatives substituted, as boric acid, salol, and hyoscyamus, the latter either by the mouth or, where there is much tenesmus, in suppository combined with opium. After the very acute stage has been passed, irrigations of the deep urethra with weak solutions of permanganate of potassium or nitrate of silver are useful. These may be administered by passing a soft catheter into the prostatic urethra and then attaching it to the reservoir containing the solution, which is allowed to run into the bladder until that viscus is filled; the catheter is then withdrawn, irrigating the urethra in its passage, and the patient voids the solution contained in his bladder, thus bringing it in immediate relation with all parts of the urethra. In the later stages the copaiba and oil of sandal wood may be again administered, and if the disease becomes chronic, irrigations and local instillations of nitrate of silver will be useful, as well as the other measures mentioned in the treatment of chronic urethritis. Tonics and other agents to overcome the sexual neurasthenia associated with chronic posterior urethritis may be called for.

Complications.—**Retention of urine** may occur, and may be spasmodic, or follow involvement of the prostate, or be the result of previous stricture. A hot sitz-bath, mucilaginous drinks, hot applications over the bladder and perineum, and the free use of opium, with perhaps leeching to the perineum, will generally relieve the patient without the use of a catheter, which should not be passed until other expedients fail, and then a soft instrument should be used.

Balanitis and **balanoposthitis** are due to the extension of the inflammation to the surface of the glans penis and the inner layer of the prepuce. They are predisposed to by uncleanliness and a long and tight prepuce, and are liable to be complicated by an inflammatory phimosis. The symptoms are burning and itching, with redness and purulent secretion, and finally superficial ulceration. The **treatment** consists in cleanliness, with the use of a dusting powder, and in some cases the injection under the prepuce of a nitrate of silver solution (gr. x to xx to water f℥i).

Phimosis following balanoposthitis is due to infiltration of lymph into the prepuce, and must be diagnosed from that due to other inflammatory causes, as chancre and chancroid. The history of the case, and the absence of external signs of chancre or chancroid, with the presence of ardor urinæ, of chordee, and perhaps of gonococci in the pus, are diagnostic points. Irrigation of the subpreputial space, followed by stripping of the urethra, will be followed by the appearance of pus if the phimosis is secondary to a urethritis, but not if it is simple or due to chancre or chancroid. It should be treated by injections beneath the prepuce of hot bichloride (1 to 10,000 to 1 to 30,000), weak carbolic solution, or lead water and laudanum, combined with elevation of the penis and rest in bed.

Paraphimosis sometimes presents itself as a complication, due to inflammatory swelling after retraction, and should be promptly reduced, and

the part dressed with a sedative lotion, such as lead water and laudanum. (See page 1131.) Inflammation of the preputial follicles going on to the formation of *abscess* is sometimes noted, and may require incision or extirpation. Follicular inflammation of one of the *lacunæ of Morgagni* appears as a little sensitive swelling under the skin, and is due to the occlusion of the mouth of the follicle. If pus forms, it may discharge externally or into the urethra, perhaps resulting in a urethral fistula. **Treatment** consists in enucleation, or in excision of a portion of the wall of the follicle. It may result in peri-urethral abscess by spreading in the connective tissue, when prompt incision should be resorted to. **Peri-urethral abscess** may develop on one or both sides of the frenum, at the bulb, or between these two points. It is most serious at the bulb, from involvement of the perineum. It may rupture into the urethra or externally, or may result in the formation of a fistula, or may burrow and cause retention of urine. **Treatment.**—It is to be treated by rest in bed and the application of anodyne fomentations, with prompt evacuation of the pus.

Cowperitis, or inflammation of Cowper's glands, is not a very frequent complication. It develops from the third to the fourth week or later, and is due to extension of the gonorrhœal process through the ducts from the bulb. It is generally unilateral, the left gland being most frequently affected. It begins as a painful swelling on one side of the perineum, which increases in size, and finally shows the signs of pus-formation, with rupture into the perineum or urethra, and troublesome fistulæ may result, and perhaps retention of urine, or rarely urinary infiltration. As the result of imperfect resolution there may persist an induration as the site for future outbreaks of inflammation. **Treatment** consists in rest, with the administration of a laxative, and locally leeching, followed by anodyne applications, as poultices, or lead water and laudanum, and an incision as soon as pus has formed.

Lymphangitis and **perilymphangitis** are occasionally present during the height of the inflammation, and are indicated by hard cord-like swellings under the skin on the dorsal surface of the penis, and often by red lines. Abscess exceptionally occurs in their course. *Treatment* consists in applications of warm anodyne fomentations, and incision if pus forms.

Gonorrhœal Bubo.—Sometimes the inguinal glands become inflamed in the course of gonorrhœa, resulting in gonorrhœal bubo, which is rather rare, and, unlike chancroidal bubo, is not prone to suppuration. Rest, anodyne lotions, and resolvent ointments will generally result in resolution. If suppuration takes place, the treatment should be the same as for the inflammatory bubo following chancroid.

Epididymitis is the most frequent complication of gonorrhœa, occurring in from six to twelve per cent. of cases. It is due to the infection travelling from the prostatic urethra backward through the ejaculatory ducts and vas deferens to the epididymis. The testicle may also be involved, in which case it is known as *epididymo-orchitis*. It is predisposed to by violent exercise and sexual and alcoholic indulgence. Its most common time for development is usually given as from the third to the sixth week, but it has been

shown by the investigations of Bergh, verified by Unterberger and Taylor, that more than one-half of the cases develop in the first three weeks, and a somewhat less number in the next three. It may occur much later, owing to fresh outbreaks of a chronic urethritis. One testicle is involved at a time, although the other may be subsequently affected. The onset is often preceded by an aching pain in the groin and pelvis, running along the cord, or by acute pain above the pubes at the edge of the rectus muscle, indicating inflammation of the seminal vesicle on that side. The discharge generally ceases at the beginning of the attack, which may be acute or subacute, the first attack being the most severe. The epididymis swells rapidly and partly surrounds the testicle, and from implication of the tunica vaginalis an acute hydrocele is usually present; the scrotum becomes œdematous and inflamed, and the first portion of the vas deferens is often enlarged and tender. Pain is very severe, is increased on motion and pressure, and involvement of the cord in the canal causes extreme pain and signs of strangulation. The irregular character of the swelling, with the history, the rapid onset, and the mildness of the constitutional symptoms, will separate it from orchitis. In untreated cases after from three to five days the symptoms decrease in severity. The most common resulting lesion is a persistent induration, due to inflammatory exudate in and around the tubules of the epididymis, especially at the globus minor, with consequent sterility so far as the involved testicle is concerned.

Treatment.—A suspensory bandage worn during the course of urethritis diminishes the tendency to epididymitis. Patients with posterior urethritis should be warned of their liability to an attack, and premonitory symptoms should be an indication for rest in bed. At the onset of the attack, rest in bed, with light diet and a preliminary purge, should be ordered. The pain is much relieved by supporting the testicles on a pillow between the thighs, or by suspension by some form of handkerchief bandage fastened around the waist. As local applications in the acute stage, lead water and laudanum, or some form of narcotizing poultice, as a combination of tobacco, digitalis, or hyoscyamus with flaxseed, applied hot, are the most useful. Guaiacol has lately been recommended, either painted on the scrotum or applied as a paste with vaseline in the proportion of one part of guaiacol to six parts of vaseline. Counter-irritation in the declining stage may be practised by the use of the actual cautery or of strong solutions of silver nitrate over the affected side. For the remaining swelling, strapping (page 193), and for the induration in the globus minor, mercurial, belladonna, and iodine ointments, are recommended. Mercury internally sometimes seems to help in removing the exudate around and in the tubules. As a rule, urethral injections are to be discontinued, although the instillation of silver nitrate (gr. i. to viii. to water f℥i) into the prostatic urethra is recommended by Boeck and Alexander.

Gonorrhœal septicæmia occurs as a complication of urethral, vaginal, and conjunctival gonorrhœa, being much commoner in men than in women. It attacks the joints, the sheaths of tendons, the bursæ, the nerves, the eye, the meninges of the cord and the brain, and the endocardium and pericardium, in about the order of frequency set down, and occurs in about two

per cent. of cases of gonorrhœa. Gonorrhœal arthritis is described under Diseases of the Joints.

Prostatitis is due to an extension of the inflammation from the posterior urethra, and may consist simply in congestion of the prostate, or may go on to actual inflammation and suppuration. It is indicated by heat and throbbing in the perineum, a sense of fulness in the rectum, increased frequency of urination, and perhaps rectal and vesical tenesmus. Pain is felt in the perineum, urethra, testicles, and down into the thighs, and fever is usually present. Congestion generally disappears in about ten days, but if suppuration occurs the above symptoms are much aggravated, and sweats and rigors may occur. The resulting abscess, which may hold from one drachm up to several ounces of pus, will most commonly point in the urethra, but may open into the rectum, the perineum, the ischio-rectal fossa, the bladder, or the peritoneum. The prognosis in small abscesses is usually favorable, but prostatic abscess may result in pyæmia, peritonitis, or fistula, and the inflammation may extend to the seminal vesicles and epididymis.

Treatment.—The treatment consists in confinement to bed, with light diet, and attention to the bowels is necessary. Opium, bromides, citrate of potassium, and hyoscyamus are useful internally. Leeches to the perineum, followed by a hot sitz-bath, and hot or cold applications to the perineum and the rectum, according to the relief given, are to be used. If retention occurs, careful catheterization may be required. Urethral treatment should be suspended. If the abscess points into the urethra, the passage of the catheter to evacuate the bladder will generally rupture it. Suprapubic aspiration and suprapubic cystotomy, with puncture of the abscess, have also been recommended in these cases. If it points towards the perineum or the rectum, a perineal incision should be employed. *Periprostatic abscess* may simulate prostatic abscess, and demands the same treatment. Chronic prostatitis is described on page 1154.

Gonorrhœal cystitis occurs as an extension of inflammation from the posterior urethra, and rarely involves the entire surface, being generally confined to the neck of the bladder. Its symptoms are those of posterior urethritis, with vesical tenesmus especially pronounced. In the chronic stage the symptoms abate in severity. There is increased frequency of micturition, with pain following, and often hæmaturia from a villous condition of the mucous membrane. Residual urine is present, and finally alkaline fermentation. The pelvis of the kidney may become secondarily involved through the ureter.

Treatment in the acute stage consists in the stopping of injections, rest in bed, light diet, alkaline diluent drinks, and local applications, either hot or cold. In subacute and chronic cases the antiblennorrhagics act well. Irrigation of the bladder should be practised with boric acid or Thiersch's mild solution, or with a weak solution of permanganate of potassium or of nitrate of silver, or with a bichloride solution (1 to 30,000). Perineal drainage may be necessary as a last resort.

Inflammation of the seminal vesicles as a consequence of gonorrhœa may be acute or chronic. Lloyd claims that it is a very frequent unrecognized complication of gonorrhœa. It comes on in the third or fourth

week, and is often associated with epididymitis. In the acute stage the symptoms resemble those of posterior urethritis and prostatitis, from which it must be excluded by rectal examination. The subacute and chronic forms are more common, the most important symptoms being sexual derangements, such as exaggerated sexual desire, delayed ejaculation, seminal emissions, mental depression, and sometimes a purulent discharge. Rectal examination shows distention of the seminal vesicles. **Treatment** in acute cases is sedative, and if pus forms it should be evacuated. In chronic cases, tonic treatment, the cure of the posterior urethritis, if it is present, and stripping or milking the vesicles through the rectum, as recommended by Fuller, are indicated.

Chronic Urethritis.—Gleet.—If instead of the discharge ceasing it persists and becomes chronic, we have to deal with chronic urethritis, or gleet. It is due to a persistence of inflammation in some portion of the urethra in the form of congested, ulcerated, granular, or papillomatous areas, with submucous infiltration as a primary cause. It is due also to stricture already formed, or to inflammation lingering in the follicles, and sometimes in Cowper's glands. It may be attended by a profuse discharge, or only a drop may be noticed in the morning, or the only indication may be the presence of fine threads in the urine, called *clap threads*, which consist of the scabs from patches of ulceration, and if examined under the microscope are seen to consist of epithelial and pus cells embedded in mucus, sometimes containing gonococci. The bulb is a favorite seat for the localization of the process, which may, however, affect any portion. In the posterior urethra lesions may be attended by no discharge, but there may be sexual and neurasthenic symptoms, frequent and painful micturition, and attacks of epididymitis. In the anterior urethra the position of the ulceration or stricture may be determined by the use of a bulbous bougie or the endoscope. Chronic urethritis may develop into an acute attack by violation of the rules of urethral hygiene, as alcoholism, venery, and violent exercise. It is probably contagious so long as gonococci are present, especially in purulent cases.

Treatment.—Internally the antiblennorrhagics are useful. Irrigation of the urethra with a solution of sulphate of zinc, alum, and carbolic acid of each 1 to 500 is used by Ultzmann. The solution is thrown into the bladder and then voided. This is followed after a couple of weeks by hot solutions of permanganate of potassium or silver nitrate; the latter is especially useful in chronic cases. Any portion of the canal may be irrigated with the same solution. When the disease is localized, a few drops of a solution of sulphate of copper or nitrate of silver, the latter varying in strength from 1 to 2000 up to twenty grains to the ounce, may be deposited on the diseased area. A special syringe is necessary, and either Taylor's or Ultzmann's (Fig. 826) may be used. Applications may also be made through the urethroscope, strong solutions of silver, iodine, sulphate of copper, and glycerole of tannin being the most valuable. In the anterior urethra the milder solutions thrown in with the ordinary syringe will answer in many cases. If no severe urethral lesion can be detected, the passage of a large steel sound every few days will often effect a cure, and is advised by Otis

as a preliminary and coincident measure in any case, as it accomplishes the absorption of the submucous deposit, which he regards as the important primary cause of the trouble. Care should be taken, however, in employing

Fig. 826.

Ultzmann's syringe.

sounds, that the urethra is gradually accustomed to their use, as they sometimes do much harm when used otherwise. The same precaution should be observed in the use of the urethroscope.

Gonorrhœa in the Female.—Gonorrhœa in the female occurs less frequently than in the male, and does not run so definite a course, but is attended by equally or more severe and lasting complications. It attacks the vulva, urethra, vagina, uterus, tubes, ovaries, and peritoneum, and is very liable to become chronic in some portion of the genital tract. Its most common sites are the urethra and the cervix uteri. There are non-specific inflammations of the female genitals due to a variety of causes, as in the male, in which the gonococcus is not a causative agent. They include uncleanliness, traumatism, masturbation, and the presence of parasites (ascarides). The vulvo-vaginitis of children may be non-specific, arising from these causes, or may be a genuine gonorrhœal infection from mediate or immediate contagion, and sometimes occurs as an epidemic in children's asylums.

Inflammation of the vulva may be primary or secondary. It is marked by heat and burning, and examination shows swelling of the labia majora and labia minora, with first a muco-purulent and later a purulent discharge, accompanied by superficial excoriation of the mucous membrane. It may extend to the urethra and vagina, and be complicated by bubo and abscess of the vulvo-vaginal glands. *Gonorrhœal bubo* is rare, as in the case of the male, and is not usually attended by suppuration. Inflammation of the vulvo-vaginal glands may be localized in the ducts or extend to the glands, in the latter case sometimes going on to the formation of an abscess, with the usual signs of inflammation, and swelling of the labium majus on the same side. It may become chronic, with persistent induration of the gland, and sometimes remains a source of contagion in such cases.

The urethra is the most frequent seat of gonorrhœa in the female, and inflammation of the urethra is usually indicative of venereal contagion. The symptoms are increased frequency of micturition, with ardor urinæ, and a discharge purulent in character. It is liable to become chronic, in which case stripping of the canal from behind forward will show the presence of pus. The process may also be localized and persistent in Skene's glands, and in the follicles around the urethra. Gonorrhœal vaginitis, formerly considered very common, is now known to be comparatively infrequent. It is observed in young women and girls, in whom the mucous membrane of

the vagina is softer and less resistant. There is deep-seated burning pain, and inspection shows at first a dry, red, glazed membrane, soon covered with a muco-purulent, later a purulent, discharge, accompanied by swelling and erosion of the mucous membrane of the orifice. There may be rectal and vesical symptoms, from the proximity of the inflammation, with reflex pain in the lumbar and abdominal regions. It may become chronic and cause a granular condition of the mucous membrane.

Infection of the os uteri is most frequent next to infection of the urethra. It is marked by redness and swelling of the os and the membrane lining the cervical canal, with muco-purulent or purulent discharge, and redness and erosion of the surrounding mucous membrane. It has a tendency to become chronic in the Nabothian glands, and may also secondarily infect the vagina. In the chronic stage it may be impossible to separate it from the discharge of a simple endocervicitis or endometritis, although infection is still possible.

In invasion of the mucous membrane of the uterus and tubes, with involvement of the ovaries and peritoneum, there ensues a variety of symptoms, as disorders of menstruation, backache, pain in the groins, mental depression, occasional outbursts of peritonitis, and sterility in most cases.

Treatment.—In acute cases it is well to insist on rest in bed, with very light, even milk, diet, with a preliminary purge. In vulvar inflammation, hot baths and thorough cleansing with hot alkaline solutions of bicarbonate of sodium or borax may be employed, after which a dusting powder may be used, or the labia may be separated by pieces of lint saturated with lead water and laudanum. Silver nitrate is useful in the declining stage. Involvement of the vulvo-vaginal glands demands sedative applications and an incision if pus forms. The chronic induration is best remedied by excision. In the urethral form the same measures that were employed in the male to render the urine alkaline and unirritating are useful; antiblennorrhagics, also, can be used with advantage. In the later stage irrigation is of value, and in chronic cases applications of nitrate of silver are indicated.

Vaginitis.—In the early stages irrigation with alkaline solutions and hot water, with, in the later stages, as the inflammation declines, solutions of bichloride of mercury 1 to 10,000 or 1 to 20,000, acetate of lead, acetate and sulphate of zinc, tampons containing subnitrate of bismuth, glycerin, and tannin, and suppositories of alum and tannic acid, are useful. Nitrate of silver in thirty grains to the ounce solution may be carefully applied to the vaginal surface also, and the application repeated at intervals of a few days if necessary. In endocervicitis the greatest care is called for to prevent infection of the pelvic structures. Irrigations and the application of strong solutions of nitrate of silver or chloride of iron, with gentle curettement, may be necessary.

Gonorrhœal Salpingitis, or Pyosalpinx.—This is a frequent and serious complication of gonorrhœa, and may exist as an acute or as a chronic affection.

Symptoms.—In the *acute* form the patient suffers from pain on one or both sides of the pelvis, the temperature is usually elevated, the pulse is rapid, and a rigor or chill may occur. In the chronic form there is, as a rule,

little constitutional disturbance, the principal symptoms being painful menstruation, sometimes pain in defecation and in coition, and a profuse leucorrhœal discharge. In both forms of the affection more or less enlargement and induration of the tubes can be discovered by a vaginal examination. *Treatment.*—This consists in rest in bed, hot external applications, hot vaginal douches, and opium if the pain is severe. If the symptoms do not subside in a few days under this treatment, and the induration does not diminish, laparotomy should be performed and the diseased tubes removed.

CONDYLOMATA, OR VENEREAL WARTS.

Moist or dry papillary overgrowths springing from the mucous membrane of the genitals are commonly known as venereal warts, but these growths may occur independently of any venereal affection, although they are quite often associated with it. The irrigating discharges from gonorrhœa, chancroid, or the primary or secondary lesions of syphilis are often the cause of these papillary growths (Plate IV., Fig. 2), but they are also not infrequently caused by the discharge from a simple balanoposthitis or an irritating vaginal discharge often observed in children and in persons entirely free from venereal taint. They consist of small or large, discrete or confluent, moist or dry papillary growths, which are exceedingly vascular, and are made up largely of connective-tissue elements, the papillæ being much hypertrophied and covered with a mucous layer; in certain localities the horny layer may be found well developed. The favorite sites for these growths in the male are the internal surface of the prepuce, the furrow behind the corona glandis, the surface of the glans penis, and the edge of the meatus; in the female they appear upon the labia, in the vagina, and about the anus. Heat and moisture, conditions which exist in these localities, are elements favorable for the development of vegetations. Phimosis often acts as a predisposing cause in the production of these growths, the concealed condition of the parts rendering the removal of the natural secretions, or the discharges due to venereal disease, difficult or impossible.

When these growths occur upon the glans penis or the inner surface of the prepuce, they exist as elevated masses, granular in appearance, which may be pedunculated or sessile; when situated upon the body of the penis or upon the edge of the prepuce, they are apt to be conical in shape and often show a predominance of the horny layer. In the neighborhood of the anus they appear as elevated granular masses flattened by pressure, while on the female genitals they are frequently seen as large masses resembling cauliflower growths.

As regards the contagiousness of these growths, much difference of opinion exists; some authorities consider them extremely so, the contagious property residing in the secretions from the growths themselves, while others believe them incapable of being transmitted in this way. If one growth is present upon the genitals, others are apt soon to develop, and there are many well-authenticated cases on record in which persons having intercourse with women suffering from genital vegetations have developed these growths, but in these cases the irritating discharge which produces the growth in the female is quite competent to produce similar growths in the man exposed to

it. The discharges from growths appearing upon active secondary lesions, such as mucous patches, may give rise to the initial lesion of syphilis.

Treatment.—Venereal warts frequently disappear if the exciting cause, such as an irritating discharge, is removed, and the parts are kept clean and dry, for moisture is an important factor in their production. Cleanliness and the use of drying powders, such as oxide of zinc, boric acid, and lycopodium, will often be followed by their disappearance. In cases of *disseminated* warts, particularly those of the horny variety, painting them with the following solution will usually promptly cause their removal: ext. cannabis indicæ, gr. x; ac. salicylic., gr. x; collodion, ℥ss. If, however, the masses are large, their removal is best accomplished by excision or cauterization. They may be excised with the knife or scissors; an objection to this method is the free bleeding which occurs, but this can soon be controlled by pressure, after which the surface from which the growths have been removed should be touched with carbolic or nitric acid and dusted with powdered iodoform or aristol. When excision is objected to, cauterization with the actual cautery, or with nitric or chromic acid, may be employed. Growths complicated with phimosis require splitting of the prepuce or circumcision before they can be successfully exposed for treatment. The large growths which occur during pregnancy should be treated by disinfectant and antiseptic lotions, and, as a rule, should not be subjected to operative treatment, as they often disappear spontaneously after labor.

CHAPTER XXXVII.

SURGERY OF THE URINARY ORGANS.

THE URETHRA.

Injuries.—The urethra is seldom wounded by objects penetrating from without, although gunshot wounds may open it, and pointed stakes may perforate it in the perineum. It is sometimes lacerated in the female during parturition, or contused so that its walls slough, and urethro-vaginal fistulæ are produced, which often involve the entire length of the canal, and almost invariably the vesical end. Plastic operations are sometimes undertaken for the repair of the fistulæ, but if the vesical sphincter is involved they are of little practical utility. The urethra itself can be easily restored by methods similar to those described below for the relief of hypospadias. Similar sloughing may take place in the male as the result of severe contusions, but is most frequently seen from urinary extravasation. The most common injury of the male urethra is its subcutaneous laceration, or so-called rupture, which is generally the result of severe blows or falls upon the perineum, of fracture of the pelvis, or of the so-called "fracture of the penis." The rupture is usually situated upon the floor of the urethra. The symptoms of this injury are the escape of a few drops of blood from the meatus, difficult micturition or retention of urine, and the sudden appearance of a tumor formed by the extravasated urine near the seat of the injury when the patient attempts to urinate. If the case is neglected, the usual picture of urinary extravasation is seen, with the formation of a local abscess when a small amount escapes, or of an extensive swelling of the penis, scrotum, and front of the abdomen in worse cases, resulting in the sloughing of the cellular tissue in these regions. This condition will be more completely described in connection with stricture.

Treatment.—This consists in not allowing the patient to pass urine when it is probable that the urethra is torn, in making a small incision into the perineal urethra behind the point of injury, and in maintaining drainage of the bladder by a catheter passed through this opening. When the injury is very slight, regular catheterization and irrigation of the urethra may be sufficient. In a few cases the divided ends of the urethra have been exposed and united by suture successfully, and if a distinct separation can be felt between them by pressure with the finger over the point of injury, this should certainly be attempted. In this operation the urethra is exposed at the point of injury, the divided ends found, all contused and lacerated tissue cut away, and the freshened ends united by sutures of fine silk, leaving the floor of the urethra open, for a complete circular suture will seldom be entirely successful, and drainage is important if any leakage takes place.

The injury may lie so deep that it is impossible to open the urethra behind it or to find the vesical end of the torn canal. In such cases the bladder should be opened above the pubes and a sound passed forward into the urethra from the bladder and made to project through a free perineal incision, by which a catheter can be inserted in the bladder as the sound is withdrawn. In any case, after five or six days have elapsed, the weekly use of steel urethral sounds should be begun, in order to avoid stricture from cicatricial contraction. In neglected cases free incisions will be necessary to combat the urinary extravasation, as will be described farther on.

Foreign bodies may be introduced into the urethra in unnatural erotic excitement or in play by children, or instruments may break in the canal. They are to be removed at once by forceps, or through an incision if impacted. Hair-pins lying with the points towards the meatus can be removed by introducing a stiff tube and catching both ends of the pin in it, or by cutting the loop with a small lithotrite and removing the pieces separately. Long pins with large heads, which have been introduced head first, can be reversed by making the point penetrate the floor of the urethra and drawing out all but the head, which is then turned over and thrust towards the meatus, and the pin withdrawn head first.

Calculi rarely form in the urethra, but vesical or renal calculi may be caught behind a urethral stricture. The presence of a calculus causes pain, obstructed micturition, and a bloody or purulent discharge. If the stone is in the prostate, the symptoms resemble those of vesical calculus. Calculi can be felt through the penis or by a sound in the urethra. They may cause perforation of the urethra and extravasation of urine. They can be removed by forceps, or crushed, or taken out through a median incision.

Congenital Deformities.—The **meatus** may be congenitally small, and is sometimes imperforate. (See Atresia of the Urethra, below.) Close contraction may also result from the cicatrix following ulceration or injury at this point. A narrow meatus may cause such obstruction to the escape of the urine as to result in hypertrophy of the bladder, dilatation of the ureters, and hydronephrosis. Even when the orifice is not small enough to interfere seriously with micturition, various nervous disturbances, such as irritability of the bladder, convulsions, sexual hyperæsthesia, and many others, may be caused by it.

Treatment.—The meatus should be enlarged by an incision upon the floor of the urethra, cutting towards the frenum, but the incision should be made in the urethra, for the skin just outside is usually distensible, and can be stretched if the inner layer be cut. The shape and elasticity of the orifice are thus preserved, and the unpleasant dribbling after urination caused by improper enlargement is avoided. A sound should be passed every day, to maintain the size of the canal, until the wound is healed. While the operation is a trifling one, death from hemorrhage has been known to follow it, and there is also danger of infection. The ordinary antiseptic precautions should be taken, therefore, and the patient should have some one near him at night in order to act promptly in case severe hemorrhage occurs during an erection while asleep. In contraction of the meatus from ulceration an

incision sufficiently free to enlarge the opening to the necessary size must be made without any attempt to preserve its shape.

Atresia of the urethra most commonly occurs at the meatus, but may involve the glandular portion or even the entire canal, an abnormal opening between the rectum and the bladder usually existing in the last variety. The urethra will often be found distended with urine behind the closed portion, and can be readily incised. An imperforate meatus can be punctured with an aspirating needle in hopes that the atresia may not extend far backward, but if urine cannot be obtained at the depth of an inch the attempt should be given up. The urethra should then be opened in the perineum if it can be felt by a rectal examination, but if it cannot be recognized, a suprapubic fistula must be made, through which it may be possible to insert an instrument into the urethra from above and find its position and extent. The urethra can be constructed by a plastic operation later.

Hypospadias and Epispadias.—The most common deformity of the urethra is hypospadias, which occurs in some degree in one out of every three hundred males born. Hypospadias is a more or less complete absence of the floor of the urethra. Epispadias is the absence of the roof of that canal. Both are the results of faults in development, the parts which should spring from each side to unite in the middle line and form the genitals failing to accomplish their union. The cause is probably the same as that of other congenital defects, and is most frequently the pressure of amniotic bands or the formation of amniotic adhesions, as described in the section on hare-lip, or perhaps the pressure of the umbilical cord drawn across the perineum. A less probable theory ascribes both deformities to a disturbance in the formation of the urethra owing to a failure of the glandular and penile portions to unite. As the anus forms separately from the rectum, so the glandular portion of the urethra and the meatus form separately from the rest and are united with the main urethra at a later period in fœtal life. The theory supposes that this junction fails to take place, or is imperfectly made, and the obstruction in the urethra by the septum between the two portions results in the retention of urine at a very early period in fœtal life, with distention of the urethra and sloughing of its floor or of its roof, similar to the extravasation of urine from urethral stricture, and thus the deformity is produced. There are three grades of **hypospadias**, according to the po-

Fig. 827.

Perineal hypospadias.

sition of the urethral opening. First, the *glandular* form, which is the lightest grade, and consists in a defect limited to the glandular urethra only, the meatus being situated just behind the glans. Secondly, the *peno-scrotal* form, in which the defect extends to the penile portion, which is usually completely absent if wanting at all, and the urethra then ends at the peno-scrotal junction. Thirdly, the *perineal* form (Fig. 827), in which the scrotum is split and the floor of that portion of the urethra is absent, the canal then opening in the perineum just in front of the membranous urethra, which is never involved in the deformity. In very rare cases the urethra is properly formed anteriorly, and only the middle portion of the canal is deficient, but, as a rule, the urethral floor is wanting from the unnatural meatus to the end of the penis. The glandular variety is very common, but the severer forms are rare. Hypospadias is rare in the female, the urethra then being represented by a groove, or there being no trace of it, the urine passing directly into the vagina from the neck of the bladder, which is usually deficient in sphincter action.

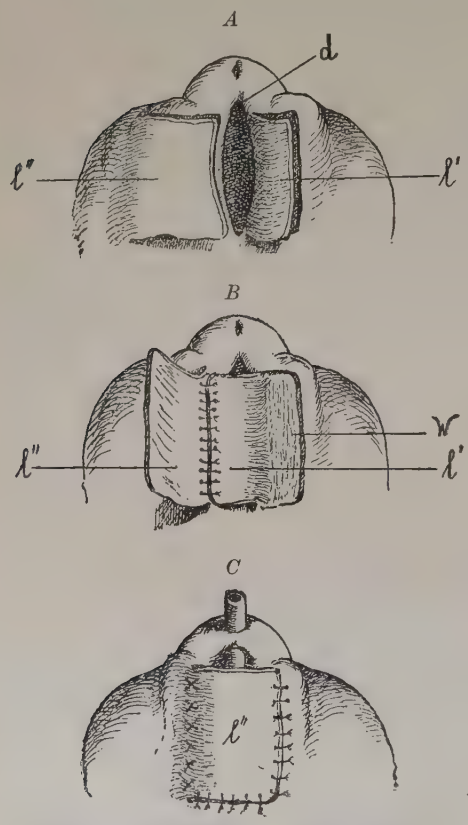
Epispadias, the roof of the urethra being absent, is often associated with exstrophy of the bladder. The corpora cavernosa are not in contact in this deformity, and lie side by side, separated by the groove which represents the urethra. Epispadias is also present in three grades—the *glandular*, the *penile*, and the *complete*, the sphincter of the bladder being divided in the last. Epispadias is, however, almost always complete, only three cases of the glandular form being on record, contrary to the rule in hypospadias, which is usually seen in the glans. Epispadias is a rare condition, but in the female it is about as common as hypospadias, and in that sex is always associated with exstrophy of the bladder.

The extreme grades of these deformities, and especially of epispadias, are associated with marked lack of development of the penis, and often with undescended testes, so that the sex of the individual is often uncertain. Many cases of so-called hermaphroditism are instances of extreme hypospadias in the male. In both hypospadias and epispadias the foreskin shares the deformity and hangs like an apron, in the one case above the glans, in the other case below it. The milder forms of hypospadias are of little clinical consequence, except so far as they affect the individual mentally, because the opening is sufficiently far forward to allow of comfortable urination and a satisfactory deposit of the semen in coition. In the higher grades of the deformity the semen would not be deposited in the vagina, and the individual would be sterile. In perineal hypospadias the individual must sit like the female in making water. These males are often deficient in sexual power or are sexual perverts, preferring to play the female in coition, although some are capable of performing both parts.

Treatment.—Both these conditions are remedied by plastic operations, the general plan of which is similar. The operations are quite difficult, and union often fails, so that repeated attempts may be necessary for success. To form the glandular urethra a deep incision is made into the substance of the glans on each side of the urethral furrow, and a stiff catheter about 15 French in size is laid between these cuts, so as to compress the tissues and deepen the urethral groove, while the outer edges of the wounds on each

side are raised and secured across the instrument by sutures or hare-lip pins. The penile portion of the urethra is formed by cutting two rectangular flaps (Fig. 828, *A*), the base of one being parallel to the urethral groove and three-eighths or half an inch distant from it, and the base of the other being at the urethral groove. Both flaps are dissected up, and the one with its base at the urethral furrow is turned over the latter, and its free edge united to the raw edge at the other side of the groove, where the free side of the second flap has been formed. (Fig. 828, *B*.) In this manner a canal is obtained which is lined throughout with epithelium, partly skin and partly mucous membrane. The flap with its base away from the furrow is then drawn over the first one, so as to cover its raw surface partially or wholly, and secured in place by sutures. (Fig. 828, *C*.) The first flap may be secured by two or three mattress-sutures through the base of the second flap; or it may be sutured with stitches which do not penetrate the epithelial coating of the canal, in order that they shall not be exposed to infection. Fine catgut or very fine silk may be employed. The scrotal and perineal portions of the urethra may be formed in a similar manner, but in the complete cases the work at the anterior end of the organ should be finished first, so as to allow the urine to pass by the posterior opening without coming in contact with the wound during its healing. When the glandular and penile portions have been formed, the opening which exists between them should be sutured, and finally the perineal opening may be closed and the urine diverted into the new channel. These small openings may be closed by freshening their edges obliquely, cutting away the surface, so that the opening into the canal is left smaller than that on the skin, and then passing sutures of fine silk, which should not enter the canal. When the opening is of considerable size, two flaps may be cut on the same principles as already described, one being turned over the opening with its epithelial surface towards the canal, and the second being sutured across the raw surface of the first to reinforce it.

FIG. 828.



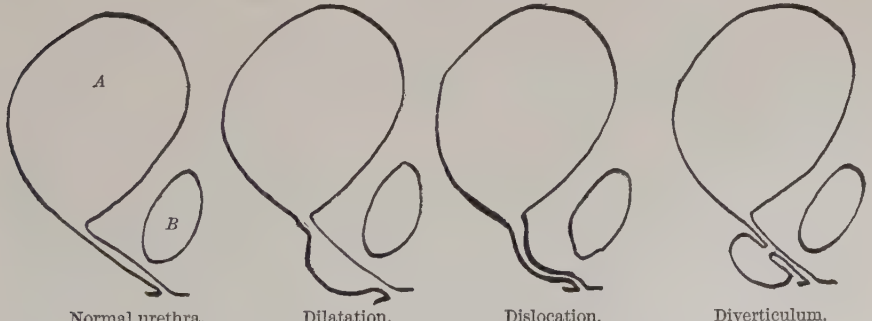
Operation for hypospadias: *d*, urethral defect; *l'*, *l''*, flaps; *w*, raw surface left by turning up the flap *l'*. *A* shows the flaps cut; *B*, *l'* sutured in position; *C*, the operation completed, *l''* covering *l'*. (Lauenstein.)

The after-treatment of these cases may be conducted in three different

ways. (1) The escape of the urine may be maintained by the perineal opening in the complete cases or by establishing perineal or suprapubic drainage beforehand. (2) A catheter may be passed through the urethra and left in the bladder to drain the urine; but this method is not so reliable, because a certain amount of urine leaks by the side of the catheter and reaches the surfaces of the wound. (3) Finally, the urine may be drawn regularly by the catheter passed by the urethra, the latter being kept clear of urine by the following method. The urethra is thoroughly irrigated, the catheter introduced, and the urine drawn off; a small amount of salt solution is then thrown into the bladder and allowed to remain, so that when the catheter is withdrawn the few drops which follow its point are the harmless salt solution instead of urine. The patients can sometimes be induced to retain the urine for from eight to twelve hours at a time, so as to reduce the number of catheterizations as much as possible. In operating upon the glandular cases, or to close a communication between the new urethra and the old in the penile portion, it is often sufficient to cause the patient to immerse the penis in a vessel of water during urination, the fluid being thus diluted at once, and to irrigate the urethra immediately afterwards. The main difficulty of these operations is not in making the canal, but in closing the connection between the different portions after they are constructed, small sinuses often persisting, which are exceedingly difficult to close, in spite of the most careful attempts. If the sinuses are very small, it is better to cauterize their edges with nitric acid and so excite cicatricial contraction.

The penis is usually very small in these cases and may be sharply flexed, and it is necessary first to restore it to the proper position. This is accomplished by cutting transversely across the skin which binds it down and then uniting the edges of the transverse wound in a longitudinal direction, dissecting up the tissue in the neighborhood so that it may slide more easily, or utilizing the loose skin of the prepuce to fill the gap. This preliminary operation should be done at a very early period, even at two or three years

FIG. 829.



Some deformities of the female urethra: *A*, bladder; *B*, symphysis. (Routh.)

of age, but the rest of the work should be left until the patient is nine or ten years old and the parts have reached sufficient size to enable flaps to be cut and readily handled. A longer delay is not to be recommended, because the erections of the organ are apt to be troublesome in the adult.

The lacuna magna and other **follicles of the urethra** are occasionally abnormally large and may be the seat of chronic inflammation or even small calculi, in which case they require free incision. True **diverticula** of the urethra are rare, but are found in the floor of the penile portion and may form sacs of immense size. These are also seen in the female (Fig. 829), and may require excision followed by plastic operations. **Prolapse of the urethral mucous membrane** takes place in women, usually as the result of stretching in parturition, combined with cystitis and straining in the act of urination. The prolapsed membrane may be intensely painful and tender and bleed when touched, forming the most common variety of the so-called **urethral caruncle.** It is best treated by excision and circular suture of the edges around the meatus.

Inflammations.—Urethritis.—The inflammations to which the urethra is subject are principally gonorrhœal, chancroidal, and tuberculous, but some pyogenic infection usually takes place at the same time. The female urethra is liable to the same infections as the male, but they are less intense and less apt to have serious complications, owing to the shorter and more direct course of the canal, which allows of better drainage. The venereal diseases are treated of in separate chapters.

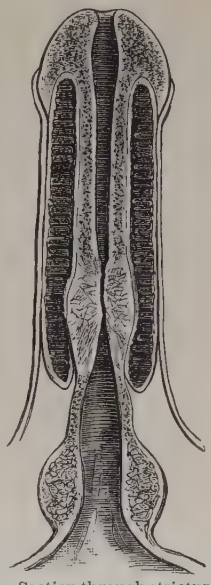
Tuberculosis of the urethra may be primary, and sometimes begins with the symptoms of an acute gonorrhœa or is inoculated simultaneously with a gonorrhœa. In other cases the first symptom is a scanty watery discharge mixed with a little blood. Extensive ulceration takes place, and if recovery should occur, which is improbable, stricture would undoubtedly follow. Tuberculosis of the urethra is almost invariably associated with the same inflammation in the prostate, to which the principal symptoms are due; hence it will be considered with the diseases of the prostate.

Periurethritis.—Pyogenic or gonococcus infection often reaches the tissues around the urethra through the follicles in the mucous membrane. These follicles may continue to be inflamed when the rest of the canal has recovered from the attack, and, the mouth of the follicle being closed by the swelling, a minute abscess may form, penetrate into the tissue outside of the urethra, and result in extensive suppuration. As a rule, these follicular abscesses are situated in the pendulous portion of the urethra, and form hard, not very painful swellings on the under surface of the penis. If left to themselves, they slowly point and discharge through the skin. In some cases the inflammation may be due to a drop of urine which remains stagnant in one of the mucous glands, but when the abscess has once formed the connection with the urethra can seldom be found. When freely opened these abscesses generally heal at once. A very different type of periurethritis is seen as the result of urinary extravasation from injury of the urethra, which causes sloughing rather than suppuration, and may destroy the submucous cellular tissue from the triangular ligament forward even to the glans. The mucous membrane in such cases is entirely dissected from its surroundings, and the cellular tissue around it comes away through the incisions made to relieve the inflammation of the parts, so that the finger may be passed forward and backward entirely around the urethra, the vitality of the latter being sustained by its longitudinal vessels. Cicatricial narrowing may fol-

low, involving the whole length of the canal, unless it be avoided by systematic dilatation by the passage of sounds.

Stricture.—Pathological Anatomy.—Stricture of the urethra is the consequence of destruction of the mucous membrane by injury or gonorrhœal or chancroidal ulceration, or of cicatricial contraction following inflammation in the cellular tissue around it. The lesion of stricture consists in the deposit of cicatricial tissue either in the mucous membrane itself or around it, but most frequently in the latter situation. (Fig. 830.) This cicatricial tissue in its early stages is soft, and microscopic examination shows fibrous tissue with an abundance of round-cell infiltration. The number of round cells diminishes later and the fibrous tissue grows very dense and hard. The cicatricial tissue may project into the urethra, but the reduction in the calibre of the canal is principally caused by the contraction of this tissue. In estimating the degree of contraction it should be borne in mind that the urethral canal is not of the same diameter from one end to the other, and that at the meatus it is naturally much smaller. (Fig. 831.) The narrowing at the meatus and the widening at the bulb are universal, but the other variations in calibre differ with the individual. The calibre of the urethra may be diminished simply by a thickening of the mucous membrane, causing it to project into the centre of the canal or to lose its distensibility. A tumor may grow upon the surface of the mucous membrane and project into the urethra, or a tumor or a collection of pus or blood in the submucous tissue may lift the mucous membrane and thus reduce the calibre of the canal. These obstructions are not called stricture, that name being limited to cicatricial contractions, and spasmodic stricture should also be excluded, for it is a spasm of the muscle surrounding the urethra. A narrowing of the canal by stricture may involve its entire length or may be limited to a very small part of the canal, and in some cases there may be a narrow band winding spirally or obliquely around the wall of the urethra.

Fig. 830.

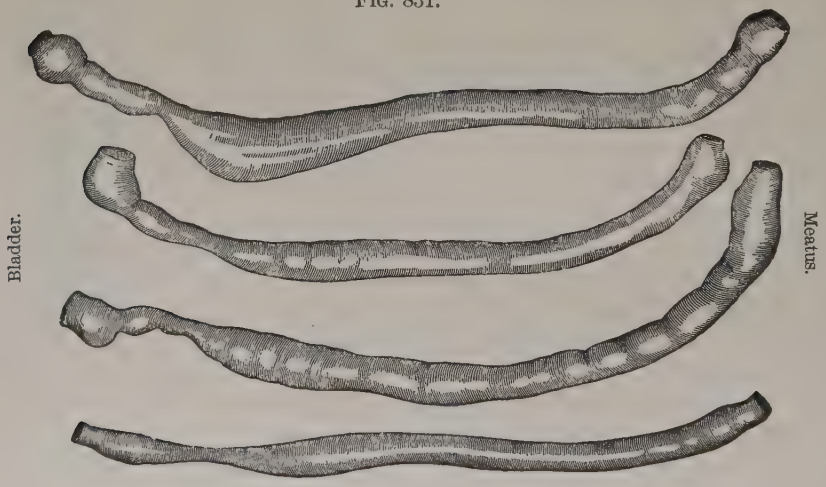


Section through stricture of the urethra, showing mass of connective tissue in the corpus spongiosum and dilatation of the posterior urethra. (Agnew.)

The changes are usually most marked on the floor of the urethra, and the orifice of the obstructed portion is therefore near the upper wall. Complete closure of the urethra by a stricture is rare, and is found only when fistulous tracts behind it allow of the escape of the urine. The prostatic urethra is exempt from cicatricial stricture, although severe spasm of the sphincter of the bladder may simulate it. Strictures are most frequent at the bulbo-membranous junction, and next in order stands the anterior portion within two inches of the meatus. While, as a rule, there is more or less infiltration and narrowing of the entire urethra with tighter strictures located at various points, in some cases the intermediate portions are healthy. Strictures admitting a sound over 20 French in size have been

arbitrarily called **strictures of large calibre**, and by many the normal narrow points of the urethra have been included among these strictures. Some have even claimed that a perfect urethra is one of equal size from end to end, and designate any reduction of its largest diameter a stricture of large calibre. It is true that in chronic inflammation of the canal, where it is desirable to treat the mucous membrane by stretching it by the passage of large sounds, a very slight narrowing may interfere with the treatment and assist in keeping up the inflammation, and may therefore require surgical attention; but it is scarcely proper to designate these narrower points as strictures on this account. The calibre of the urethra bears some proportion to the size of the penis: according to Otis, a penis three inches in circumference should have a urethra of 30 French; one of three and a

FIG. 831.



Paraffin casts of the normal urethra. (Gerster.)

quarter inches, of 32 French; one of two and three-quarter inches, of 28 French. Some surgeons think these figures too large, but in treating stricture we have usually aimed at obtaining a calibre of 30 or 32 French, and have had no accidents attributable to this cause, and but few recurrences of the stricture. The mucous membrane behind a stricture is usually in a condition of chronic inflammation, because the narrowing of the canal retains the urine and purulent discharge, and ulceration frequently exists at this point. The urethra behind the obstruction is apt to be dilated, owing to the increased pressure necessary to expel the urine, and the pressure may extend backward and dilate the bladder, the ureters, and even the pelves of the kidneys. The incomplete evacuation of the urine also leads to infection and disease of the bladder and kidney, and sometimes a stone is formed in the bladder or urethra. Stricture of the urethra is rare in the female, probably because gonorrhœal urethritis is less severe in that sex. Obstruction of the urethra usually begins in from four to eight months after an injury, and in from two to ten years—on the average four years—after an attack of gonorrhœa.

Symptoms.—The symptoms of stricture often begin long before any obstruction is noticed, for a slight discharge of purulent or watery material is caused by the chronic inflammation of the mucous membrane behind the stricture, and a dribbling of urine occurs at the end of micturition because the urethra has lost its natural elasticity and fails to expel the last drop promptly. The discharge may be so slight as to be noticeable only in the morning, when no urine has been passed for several hours. The difficulty in making water develops gradually, and if the bladder be healthy and hypertrophy early a considerable amount of obstruction may exist without the patient's knowledge. The first marked symptom may be an attack of retention, owing to errors of diet, exposure to cold, alcoholism, a fresh urethritis, or some such condition, causing the mucous membrane to become swollen about the stricture and block the canal completely.

In such cases a patient who has been making water without much difficulty suddenly is unable to pass any urine. The bladder becomes distended, and intense pain is caused by the spasmodic efforts to evacuate it. A slight rise of temperature may be observed, and if cystitis or pyelitis be present this rise will be marked, and there will be a chill. Uræmic symptoms may also develop under these circumstances. If the bladder and kidney are healthy, the general symptoms are limited to discomfort and pain. If not soon relieved, the pressure behind the stricture may force the urine through some weak point in the mucous membrane into the submucous tissue and cause urinary infiltration.

Extravasation of urine may take place at any point from the triangular ligament to the glans penis, but is most frequent in the deeper portions of the canal. The urine spreads through the submucous tissue and as far outward as the superficial perineal fascia, which prevents its extension backward, or to the thighs, and forces it to ascend on the abdomen. The penis and the scrotum become intensely swollen, and the swelling sometimes reaches as high as the umbilicus. The skin is œdematous and red, and there is a hard, brawny infiltration which pits on deep pressure. If left unrelieved, the redness becomes dusky, the circulation is impaired, points of softening and fluctuation appear, and if an incision is made at these points it will be found that the subcutaneous tissue is gangrenous throughout the infiltrated part. A foul, serous fluid, with an odor of ammoniacal urine, surrounds the sloughs.

If incisions are made early, the spread of the urinary infiltration may be prevented, the fluid escaping from the wounds and the sloughing subcutaneous tissue slowly separating and leaving granulating surfaces behind it in favorable cases. The large subcutaneous spaces left by the sloughing of the cellular tissue then heal, but if the leakage of urine from the urethra still continues because the obstruction persists, the urine makes channels for itself through the tissues, and sinuses are formed, which spread in a tortuous manner in all directions, so that when the patient attempts to make water the urine escapes from a dozen or more openings in various parts of the scrotum, the penis, and even the abdomen. In unusually strong and healthy men a spontaneous cure of the extravasation by the formation of these fistulæ is not uncommon, but a fatal issue is to be expected in those

who are less robust, and especially if the bladder and kidneys are already diseased. The constitutional symptoms of urinary extravasation are usually very severe, for in addition to the ordinary symptoms of cellulitis, such as pain, fever, rigors, and prostration, the constituents of the urine are absorbed by the tissues, and a condition of uræmia is produced, with contracted pupils, a urinary odor to the breath, a hard, quick pulse, dyspnœa, coma or delirium, and, finally, convulsions. Some of these uræmic symptoms are undoubtedly caused by interference with the action of the kidneys by the damming back of the urine, but the majority are the result of absorption of the extravasated urine. In other cases the urinary extravasation takes place much more slowly, only a few drops escaping at a time, and localized abscesses are produced, which, on being opened, result in the formation of urinary fistulæ in the perineum and scrotum. As a rule, urinary infiltration does not affect the skin itself, and it is only in extreme cases that any considerable amount of skin becomes gangrenous, although in such cases the entire covering of the penis and scrotum may be lost.

While acute retention may have these immediate consequences, the more chronic form results in over-distention of the bladder and an increased backward pressure on the kidneys, with a greater liability to infection and inflammation of both. In such cases the patient is unable to evacuate the bladder completely, and gradually that organ becomes distended to its utmost and loses its contractile power, when a condition of overflow is established in which the urine constantly dribbles away. In such cases the complication of kidney disease will usually be found, and its symptoms are added to those of the urethral condition. Such patients are anæmic, and worn out by suffering and loss of sleep, the establishment of leakage by overflow being preceded by a long period of frequent and painful micturition. The micturition is not increased in frequency at night, thus differing from the symptoms of prostatic hypertrophy. Patients with tight stricture usually suffer an impairment of sexual power, and may become impotent.

Prognosis.—The prognosis of a stricture depends upon its extent rather than its calibre, for a stricture involving a large part of the urethra will cause more obstruction to the passage of the urine and be more liable to the accidents of retention and urinary extravasation than a narrow band of the same calibre. If the bladder is healthy, and tolerance is established so that the urine is regularly evacuated, even if the intervals be frequent and the amount be small, the patient may enjoy tolerably good health. If his habits are irregular, however, acute retention may set in at any moment, and in any case the symptoms will constantly grow worse. The danger to life depends upon the condition of the bladder and kidneys. The presence of cystitis or pyelitis renders the prognosis very bad, and also increases the danger of treatment.

The Use of Bougies and Catheters.—Urethral Fever.—In any examination or treatment of the urethra the most thorough antiseptic precautions are necessary. The instruments, the hands, and the penis must be most carefully cleansed and sterilized. If antiseptic precautions are not observed, urethral fever may occur, either at once or the next time that the patient passes water. The fever begins with a severe chill, and the

temperature may reach 105° F. (40.5° C.) or 106° F. (41° C.), but usually promptly subsides. This chill and rise of temperature follow every passage of urine over the wounded canal or the introduction of any instrument. The chill may be prevented or controlled by the administration of quinine, ten or fifteen grains being given at a dose an hour before the instrumentation or micturition is expected; and also by the administration of salol, which is excreted by the kidneys and partially sterilizes the urine. These symptoms are known as *urethral fever*, and were formerly very frequent in all urethral surgery, and supposed to be of nervous origin. They are probably due to the absorption of toxines produced by bacterial growth within the canal. If the condition lasts for any length of time a true septic fever is established, with irregular exacerbations, purulent urethritis or cystitis, secondary pyelitis, and general septicæmia or pyæmia.

Sterilization of Instruments and of the Urethra.—Metal and rubber instruments may be sterilized by boiling, although the rubber is injured by prolonged or repeated boiling, but the gum instruments should be carefully washed with soft soap, and then laid for fifteen or twenty minutes in a 1 to 1000 solution of bichloride of mercury, and again carefully rinsed in sterilized water before they are introduced. In cleansing catheters a strong stream of water should be driven through the instrument, and the catheters should be filled with the bichloride solution and left to soak in it for half an hour or an hour. The urethra should be irrigated with some antiseptic solution, such as the boro-salicylic solution. Some surgeons prefer bichloride of mercury in a solution of 1 to 5000, but this is often painful and irritating. In spite of every care there will often be some infectious matter retained behind the stricture, and infection from this source is not uncommon. The patient should be directed to pass water before the examination, if possible, in order to wash out the urethra behind the stricture.

For lubrication any sterilized medium, such as vaseline, glycerin, or boroglyceride, may be employed, but sweet oil is the best in cases of narrow stricture. These substances are sterilized by heat, for it has been proved that oil and vaseline cannot be sterilized by the addition of carbolic acid even in large quantity. The lubricant is rubbed upon the instrument with the sterilized finger, or the sweet oil may be injected into the urethra, the latter procedure being useful in tight strictures. If applications are to be made to the canal, glycerin should be employed, as the oil would protect the mucous membrane. The metal sounds should be warmed before introduction.

Instruments for Examination.—The instruments used in the examination of the urethra may be flexible or stiff, the former being less likely to do injury, and the latter, when made of metal, being easier to render aseptic. For sizes under 12 French, flexible instruments should be employed, and over that size the metal sounds are more convenient. Solid instruments, called bougies or sounds, are used for examination, and hollow bougies, or catheters, for drawing off the urine. These instruments are made in various sizes, which are known by certain numbers, but three different scales are in use to designate them, the American, English, and French, or Charrière. The numbers of the American scale give the diameter of the sound in half millimetres, while the English scale is purely arbitrary. The French or

Charrière scale is most frequently used, and its numbers give the diameter of the instruments in one-third of a millimetre, and therefore nearly correspond with the circumference in millimetres. No. 3 is thus 1 millimetre in diameter and 3.1416 millimetres in circumference, and No. 30 is 10 millimetres in diameter and 31.416 millimetres in circumference.

For very tight strictures filiform bougies of whalebone are employed of a diameter of one millimetre or less, straight, or bent to an angle or made spiral at the end. Flexible bougies and catheters may be made of soft rubber, but the smaller instruments need to be stiffer, and are made of linen or silk thread covered with shellac, often called "gum" bougies. Sometimes a soft wire stylet is inserted to stiffen them and give them certain shapes. A very useful flexible instrument is the "whip bougie," which tapers from a filiform point to 15 French and is very long. The stiff bougies are generally made of metal and are called sounds, those of polished steel being most common and most useful. The sounds have a straight shaft, and the end bent to the curve of a circle three and one-quarter inches in diameter, which is the subpubic curve of the normal urethra, and the beak should never include more than ninety degrees of the circle. The sounds should taper towards the point, which should be two sizes smaller than at the curve.

Introduction of Instruments.—The method of introducing these instruments is as follows. The patient lies upon his back, and the surgeon, standing by his side, takes the penis in one hand, while with the other he gently passes the instrument into the canal. If a flexible instrument is used, the penis is held vertical and placed somewhat on the stretch, so that the canal shall be rendered rigid. In the introduction of a stiff instrument its point should be gently inserted into the meatus, and the sound then held steady, with its shaft parallel to Poupart's ligament, while the hand holding the penis gently draws the organ up over the sound. Very slowly and gently the advance is made, with slight rotary movements, until the sound has passed the peno-scrotal junction, when the beak of the instrument should be turned backward (towards the bladder), and the shaft brought into the median line of the body. The hold upon the penis is then relaxed, the handle of the sound is slowly raised, and the instrument is allowed to slip downward of its own weight, following the natural curve of the urethra. The shaft thus gradually becomes vertical, showing that the point of the sound is in the neighborhood of the triangular ligament. If it is necessary to pass the sound into the bladder, the handle is turned still farther downward in the same curve towards the patient's thighs with great gentleness, the sound being allowed to enter simply by its weight and without pressure. This manœuvre can be assisted by laying the other hand flat upon the surface of the abdomen, just above the pubes, and drawing the skin downward, which relaxes the tension of the parts at the root of the penis.

With a very relaxed urethra there may be obstruction to the sound at the peno-scrotal junction and at the triangular ligament, the point of the sound pushing the abnormally soft urethral wall before it like a pouch. The former is overcome by pulling the penis strongly up on the sound towards the umbilicus, and the latter by lifting the sound a trifle when its

end impinges on the surface of the ligament. The point of the sound should be kept against the roof of the urethra, as it provides a much firmer guide to the instrument than the more distensible floor of the canal, and obstructions are also more likely to be found on the latter. The entrance of the sound into the bladder is proved by the fact that its beak can be freely turned from side to side, and the patient has a sensation as if he were making water. The point of a filiform is so fine that it may be caught in one of the small lacunæ or the ducts of glands in the mucous membrane, and it should be slightly withdrawn if it meets with any obstruction, and an attempt made by bending the penis or the instrument to cause the latter to slip along another portion of the urethral wall before it is concluded that the obstruction in question is a stricture. If there is a stricture and the filiform cannot be made to pass, it should be inserted as far as possible and then another filiform passed alongside of it. If three or four instruments are together in the urethra, one after another being tried, it is often possible to introduce one of them into the stricture when a single bougie would not enter. A temporary bend is easily given to the tip of the whalebone filiform by pinching it between the finger-nails. The angular filiforms often enter where the straight would not, and the same is true of the spiral shapes.

When a filiform has been passed into the stricture in a difficult case and an operation is proposed, it is wise to keep the bougie in place until the operation. To secure a bougie or catheter in the urethra, a "clove-hitch" knot should be made around the instrument with a silk thread, and the ends of the latter secured to the penis by rubber plaster or tied to the hair of the pubes.

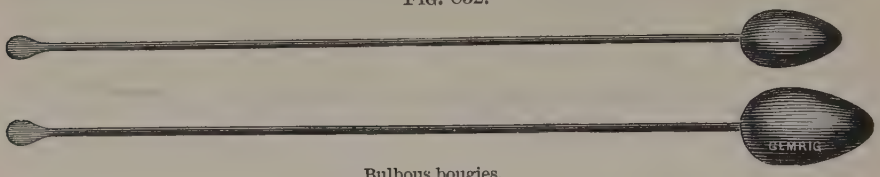
Accidents.—There may be some pain in passing water and a slight mucous discharge from the urethra after the introduction of instruments. This can be lessened by alkalinization of the urine. Epididymitis may also follow urethral instrumentation from infection of the seminal ducts by urethral discharge or by an unclean instrument. False passages may be made by penetration of the urethral mucous membrane by a stiff instrument used with too great force, an accident which usually causes pain and hemorrhage and sometimes an abscess.

Catheterization in the Female.—The introduction of the female catheter is usually very easy, unless the parts are abnormal, either congenitally or as a result of parturition and its accidents. The same care as to asepsis is necessary as in the male, lest a cystitis develop, and this compels the rejection of the older methods of introducing the instrument by the touch alone. The genitals should always be washed and sterilized, the labia held apart, and the catheter introduced by the aid of sight so that it shall touch nothing but the meatus.

Anæsthesia.—A general anæsthetic is seldom necessary for the introduction of these instruments, but cocaine may be employed locally. In the use of urethral injections of cocaine there appears to be unusual liability to poisoning by absorption, so the solutions used should be only two, or at most four, per cent.; not over fifteen minims should be employed, and the urethra should be irrigated with warm sterilized water in order to remove the cocaine as soon as the anæsthetic effect has been obtained.

Diagnosis of Stricture.—The diagnosis of stricture is made by the local examination, for which the bulbous bougie (Fig. 832) is the proper in-

Fig. 832.



Bulbous bougies.

strument. When introduced into a stricture through which it just passes, the broad shoulder of the bulb is grasped by the stricture on withdrawal, so that the exact depth of the narrowest point may be ascertained by placing the finger on the stem of the instrument at the meatus, withdrawing it, and measuring the distance marked. The peculiar jump which a bulb gives when withdrawn through a stricture is an important diagnostic sign, as the sensation is much less distinct when the obstruction is the result of the projection of a tumor into the canal, or some such cause. The bulbous bougie is of little value in the deep urethra, as it may catch upon the edges of the opening in the triangular ligament and simulate the existence of a stricture. It is also difficult to dislodge the instrument in that case, and the necessary force may break it and leave the bulbous end in the bladder; consequently it should not be introduced over six inches from the meatus. Before examining a urethra for stricture a narrow meatus must be divided. The largest possible instrument should be introduced first, for it more readily overcomes muscular spasm and is less apt to catch in the lacunæ and false passages. Successively smaller bulbs are employed, down to 10 French, until one is found which passes the stricture, but under that size flexible bougies are to be used. The *urethrameter* is an instrument which can be expanded after introduction into the urethra, and which will show on a dial the exact limit of distensibility at any point of the canal. The best known is that of Otis. It is intended to measure the urethra in order to demonstrate the existence of strictures of large calibre, but is useful also in locating strictures which exist behind a meatus narrower than themselves when it is not desirable to enlarge that orifice.

Treatment.—Only two methods of treating strictures need be considered—namely, dilatation and urethrotomy. Electrolysis has no advantage over the cutting operation if the currents are strong enough to destroy the mucous membrane, and none over dilatation if very feeble currents are employed.

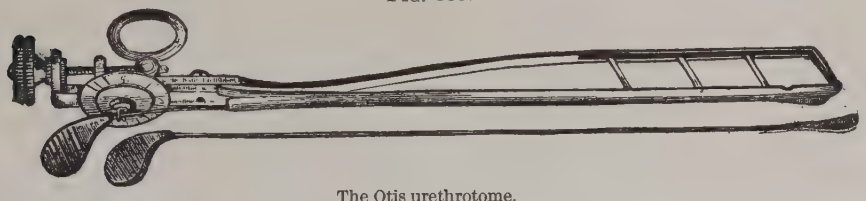
Dilatation is carried out by the introduction of instruments of constantly increasing diameter, passed at regular intervals, the frequency of which depends upon the tightness of the stricture and its tendency to recontraction. The method of rapid dilatation, by which the stricture is also lacerated, is too uncertain and dangerous, and has fallen into disuse. If the stricture is very tight, it may be necessary to begin with a filiform bougie, and if retention is present when treatment is begun, the filiform should be left in the bladder, for enough urine will escape by its side to relieve the

worst symptoms of the retention. A filiform which is tightly grasped by the stricture at the time of introduction becomes loose in a few hours owing to its pressure upon the tissues about it. Thicker filiforms are introduced, or several of the same size, dilating the stricture until a fine flexible instrument may be passed through it. The patient is kept in bed during this continuous dilatation. He is then allowed up, and larger instruments are passed daily until the stricture has reached the size of 15 or 20 French, and then the intervals may be lengthened to from three to seven days, for after this point the improvement will not be so rapid. The introduction of instruments through the stricture not only stretches the narrowed part but brings about a change in the tissues, for their circulation is improved, the round-cell infiltration melts away, new vessels form in the fibrous tissue, and absorption is gradually produced. If false passages are made by the instruments used in dilatation, no instrument should be passed for at least a week, in order to give them an opportunity to heal. Sometimes they can be avoided at the next introduction of the sound by keeping its point directed against the roof of the urethra, as they are apt to be situated upon the floor.

Urethrotomy may be internal or external.

Internal urethrotomy is now usually performed with an instrument which stretches the canal and holds the mucous membrane steady while a concealed knife is drawn through it, dividing it to any extent. The incision made by the knife is very shallow, except where the tension of the parts across the instrument is very great. Otis's dilating urethrotome is the instrument generally preferred. (Fig. 833.) When the stricture has been located with the bulbous bougie, the instrument is passed through it and

Fig. 833.



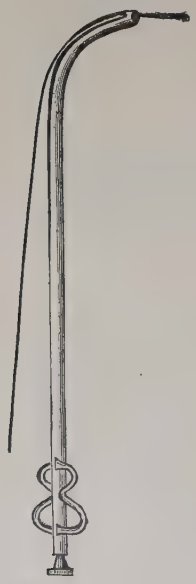
The Otis urethrotome.

screwed up until the desired degree of dilatation is obtained, as shown on the dial, or as near that as the tension of the parts will allow, and the knife drawn once through the stricture and then pushed back again. If the required size of the urethra has not been obtained at the first attempt, a second cut is made in the same manner. The instrument is then partially closed, rotated on its long axis half-way in order to free the branches from the edges of the divided mucous membrane, and withdrawn. Smart hemorrhage may follow this procedure, but it is usually soon arrested by pressure. If it be troublesome, a stout rubber catheter should be inserted and a bandage applied to the penis. A sound of the full size should be passed twenty-four or forty-eight hours after the operation, and in ordinary cases it will be unnecessary to pass it again for five or six days. Our own practice is to pass the sound once a week after an operation of this nature unless

there is a tendency to rapid contraction, and then it may be passed twice a week. A tendency to contraction usually indicates that the cicatricial tissue has not been entirely divided, and in some cases complete division is impossible on account of the great extent of the lesion. After weekly use of the sound for three months it should be passed once a month for a year.

Before introducing the urethrotome, the meatus should be enlarged to the necessary size with a bistoury. The Otis urethrotome can only pass through a stricture of about 15 French, and for smaller strictures it is necessary to use the Maisonneuve instrument, which consists of a grooved staff, along which a stylet carrying a triangular knife with a blunt apex is pushed from before backward. The instrument has a very fine flexible bougie, which can be introduced and then screwed to the end of the urethrotome, so that it guides the latter through a very tight stricture. When the urethra has been somewhat enlarged the Otis instrument can be used. Internal urethrotomy can be performed in any part of the canal, but is now seldom used for attacking strictures in the membranous urethra, or deeper, on account of the danger of uncontrollable hemorrhage. The only other danger of the operation is septic infection, and this can be avoided by full antiseptic precautions, unless the stricture is so tight that the urethra behind it cannot be thoroughly irrigated. If there are signs of considerable inflammation behind a tight stricture (local tenderness, foul discharge, fever), the urethra should be opened in the perineum in order to afford drainage, otherwise urethral fever or sepsis will follow. Slight strictures can be divided painlessly by the use of cocaine with the precautions already noted, but very extensive or tight strictures should be treated under general anæsthesia.

FIG. 834.



Tunnelled catheter.

External urethrotomy is now seldom employed except for deep strictures or for the purpose of drainage with internal urethrotomy as just mentioned. The operation is performed by introducing a guide into the urethra as large as circumstances will permit. In some cases only a filiform can be passed through the stricture, and in others no instrument will enter it, when the operation must be performed without a guide.

External Urethrotomy with a Guide.—If possible, a metal guide should be used. For this purpose there is no instrument more useful than the tunnelled sound or catheter recommended by Gouley. (Fig. 834.) This instrument has a perforation at the point, through which the filiform, which has been passed through the stricture, may be threaded, and the instrument is then pushed down along the filiform, which guides it through the stricture. It is unsafe to use much force, for the edge of the opening in which the filiform plays may cut the bougie, and when the guide is thus lost a false passage may be made. The filiform, moreover, may enter a false passage and, curling up in it, may appear to be in the bladder, and if the surgeon introduces the tunnelled sound with force, that instrument necessarily follows the guide and may add to the

injury. In order to overcome these objections the tunnelled catheter has a hollow shaft instead of a solid one, through which the urine can flow, and it can thus be proved that the instrument has entered the bladder.

The guide having been introduced into the bladder, an incision is made in the median line of the perineum from the posterior limits of the scrotum to the anterior edge of the sphincter ani. This incision is deepened until the bulbous urethra is reached. If the bulb is very well marked, it can sometimes be drawn forward by a retractor and the troublesome hemorrhage from this source avoided, but in the majority of cases the bulb does not bleed very profusely. The incision is deepened in the median line until the urethra is reached, when the guide can generally be felt with the tip of the finger and the canal opened. A director is inserted, the staff removed, and then a small silver female catheter can be slipped backward along the director into the bladder. When the anterior strictures have been dealt with by internal urethrotomy, a large sound is carried down from the meatus to the wound and then passed onward into the bladder. If any obstruction is met with in this region, it is removed by passing a director into the canal and nicking the obstructing point with a blunt-pointed knife. Occasionally there is troublesome oozing of blood, or even active hemorrhage from the deeper parts, which persists after the operation. In such cases a *canule à chemise* is constructed by inserting the end of a catheter through a hole in a square piece of gauze, and tying the latter firmly around the catheter by a string embracing the edges of the hole in the gauze. The catheter is inserted in the bladder and the gauze spread over the edges of the wound so that it has the shape of a funnel, the apex being in the bladder. Strips of gauze are packed in the funnel thus formed until sufficient pressure is obtained to control the hemorrhage.

External Urethrotomy without a Guide.—If no guide can be passed, the operation becomes one of the most difficult in surgery, and even experienced men occasionally fail to find the urethra. The patient should be placed in the lithotomy position squarely on his back, in front of a good light, and the incision very cautiously made exactly in the median line, and deepened layer by layer in order to recognize the different parts as they are divided. Retractors should be placed in the wound, silk sutures passed through its edges being best for this purpose, and the assistants should be careful to maintain equal traction on both sides, so as not to mislead the operator. The umbilicus of the patient should be in full view, so that the operator may be perfectly certain of the direction of the median plane of the body. When the deepest parts are reached, a finger in the rectum may assist in giving the exact relations of the urethra, and the apex of the subpubic arch can also be used as a guide. If there has been but little infiltration of urine, the urethra may be recognized when it is reached, but when there are fistulæ and cicatricial tissue, or where there is actual extravasation of urine at the time of operation, all landmarks may be lost. The surgeon should then carry the knife gradually deeper in the median line, watching for anything which looks like mucous membrane to indicate that the urethra has been opened. He may be misled by the endothelial lining of the vessels in the cavernous tissue, which often resembles the diseased mucous membrane of the urethra. Any opening which appears to present mucous membrane should be cau-

tiously explored with the probe and director, using the greatest gentleness. When the urethra has been opened, a probe or director will pass readily backward to the bladder or forward towards the meatus, and if there is the least obstacle to its passage the operator may feel certain that he is merely pushing the instrument parallel with the urethra in some of the cellular planes.

If the urethra cannot be found and the symptoms are acute, with much extravasation of urine, lateral incisions may be made on each side at right angles to the median one, and the patient allowed to recover from the anæsthetic. In the majority of cases it will be found that the urine passes by the wounds, and the opening into the urethra can be discovered then, or after the sloughs have separated. If urinary extravasation exists, the surgeon should not be content with merely opening the urethra, but should make incisions through the skin and cellular tissue of all the inflamed region in order to allow free escape to the urine. The scrotum, the penis, the tissues of the perineum, and the anterior surface of the abdomen must all be treated in this way, and all loose sloughs removed. An anæsthetic is not necessary for these incisions, as the parts are generally insensitive and the patient is often so weak that anæsthesia would be dangerous. In extreme cases it is best not to attempt an external urethrotomy if no guide can be passed, but to be satisfied with these free incisions, one of which should be made deeply in the median line of the perineum in the direction of the urethra without endeavoring to find that canal, as the urine will probably make its own way out. In some cases it may be necessary to relieve the bladder at once, when a suprapubic cystotomy may be done and an instrument passed forward into the urethra from the bladder—*retrograde catheterization.* In other cases suprapubic aspiration of the bladder may be performed for temporary relief. The after-treatment of external urethrotomy consists in the maintenance of a drainage-tube or catheter in the bladder for two or three days, after which the wound can be packed if the bladder is healthy. If cystitis exists, drainage should be maintained longer. The sounds must be introduced at regular, slowly lengthened intervals, as after internal urethrotomy.

In Syme's method of external urethrotomy the incision is made at the seat of the stricture upon a grooved guide with a shoulder which rests against the anterior face of the stricture. In Wheelhouse's method a sound with a bulbous end of peculiar shape is passed down to the stricture and the urethra opened anteriorly to the latter. The bulbous end of the sound is brought out of the wound and answers as a retractor, exposing the anterior end of the stricture, so that the entrance to it may be sought with a probe under the guidance of the eye. These methods are now seldom employed.

In cases of stricture with very dense masses of cicatricial tissue some surgeons cut away all the scar-tissue after performing external urethrotomy, but this is seldom necessary, as it melts away spontaneously after free incision. *Resection* of the stricture followed by suture of the urethra appears to be growing in popularity and is well suited for deep strictures limited to a small extent of the urethra, especially those of traumatic origin. The best method is that of Guyon, who resects the floor and sides of the canal, leaving the roof untouched, which is usually not much altered, and sutures the wound as described in rupture of the urethra.

Aspiration of the Bladder.—In cases of acute retention of urine when no instrument can be passed and external urethrotomy for some reason is inadvisable, and when the hot bath and full doses of opium have no effect, the patient's sufferings may be relieved by aspiration of the contents of the bladder through a hollow needle introduced above the pubes. When the bladder is fully distended its anterior wall is uncovered by peritoneum for an inch above the pubic bone in the median line, and in some cases this interval is even wider. (See under Suprapubic Cystotomy.) The needle should be inserted exactly in the median line and close to the pubic bone, and should be as fine as consistent with easy withdrawal of the urine, a calibre of about one-twenty-fifth of an inch being proper. The needle and the skin should be carefully sterilized. Strong aspiration should be kept up as the needle is withdrawn after the fluid has been evacuated, as in this way the risk of escape of urine into the cellular tissue in front of the bladder is reduced to a minimum. The bladder has in some cases been evacuated by aspiration every twelve hours for days at a time, but it is not advisable to repeat the operation too frequently, as there is some risk of infection.

Choice of Treatment.—The choice of treatment in stricture will depend upon the variety of lesion and upon the accompanying infection. In strictures situated in the anterior four inches of the canal an internal urethrotomy is safe and yields better results than continuous dilatation, which is very slow and exposes the patient to greater danger of infection on account of the more frequent instrumentation which is necessary. Dilatation, however, may be employed for soft strictures in this part of the urethra, recognized soon after the gonorrhœal infection which has occasioned them, and limited to a small part of the canal. On the other hand, if there is infection of the urethra or cystitis it is wise to combine the external and internal operations, and maintain drainage of the bladder for some days afterwards, in order to lessen the danger of infection of the wound and to relieve the bladder at the same time.

Deep strictures may be successfully treated by dilatation unless they are traumatic in origin or there is much cicatricial tissue. In the latter cases a cutting operation is almost imperative if a permanent result is to be obtained. In strictures deeper than four and a half inches the external operation is advisable on account of the danger of hemorrhage and the greater liability to infection because of the difficulty of maintaining strict asepsis of the deep urethra. It is true that after internal or external urethrotomy regular treatment with the sound is necessary, but the patient is at once restored to the full use of the canal, and it is not necessary to pass the sound so frequently as in the first few months of treatment by dilatation.

Rapid dilatation of the urethra or divulsion has fallen into disfavor because of the severe traumatism inflicted, by which the mucous membrane is badly torn and contused and rendered more liable to infection, while the results are no better than those of an internal urethrotomy.

After-Treatment.—After the urethra has been brought to its proper dimensions by any of these measures the patient should have a sound passed once a month for at least a year, and after that at intervals of three months until it is evident that no recontraction will take place. In any urethra

which has been the seat of stricture the surgeon should aim at obtaining a calibre of at least 30 French, and in a large penis of 32 or 34 French, if the calibre is to be maintained, for very full dilatation of the canal is necessary in order to secure complete absorption of the cicatricial tissue about it. Even larger instruments than these must be passed in individuals who are suffering from gleet, in order fully to stretch the widest portions of the canal.

Urethral Fistulæ.—Extravasation of urine may result in the production of fistulæ, but they usually heal after thorough division of the stricture. They should, however, be sufficiently laid open for drainage or curetting. Large fistulæ on the lower surface of the penis may leave very extensive gaps in the floor of the urethra and may require plastic operations similar to those described for hypospadias. The perineal incision in external urethrotomy sometimes fails to close, and may necessitate a plastic operation.

Spasm of the Urethra.—Spasmodic contraction of the circular muscular fibres surrounding the deep urethra may cause symptoms of stricture. It is even claimed by some that in the majority of cases obstruction of the deep urethra is spasmodic, but there can be no question that cicatricial strictures frequently occur in this region. Spasm of the urethra may be a reflex result of irritation of the mucous membrane of the canal or of the bladder, and most frequently the irritation is due to a moderate stricture anteriorly or a slight prostatitis. The spasm may be so intense as to prevent even the passage of a bougie. In some cases it is constant and persists for years, the patient never being able to make water without an effort, while in other cases it is intermittent and there are longer or shorter periods of freedom. Spasm of the urethra is to be treated by removing the cause when it can be ascertained, and by the passage of very large sounds to the bladder. In this condition a large blunt-pointed sound will often enter the bladder by steady, gentle pressure maintained for some minutes even when the introduction of smaller instruments is impossible, the sharp points of the latter probably irritating the muscle to closer contraction.

Tumors of the urethra are rarities, the least rare being small mucous polypi. The canal is sometimes invaded by malignant disease of neighboring parts, but primary cancer is too rare to require description. The polypi are recognized by endoscopic examination, and in some cases they may protrude from the meatus. The only symptoms they excite are slight obstruction to urination and a scanty mucous discharge. They are readily removed by avulsion.

INJURIES AND SURGICAL DISEASES OF THE BLADDER.

Malformations.—The bladder is in very rare cases entirely absent, the ureters opening into the urethra, vagina, or rectum. In the fœtus the lower end of the bowel is at first in connection with a canal leading to the allantois, and the ureters discharge into the same passage, the first sign of the bladder being a sac-like dilatation of the allantois canal in front of the rectum. As development proceeds, the bladder and rectum become separated, the anus forms, and the urethra appears anteriorly, being formed as already described. Defects of development are found on both the anterior and pos-

terior walls of the organ. On the posterior wall, owing to the lack of formation of the septum between the bladder and the rectum, both may open into a common cloaca, or, the anus being imperforate, the feces may be discharged through the urethra by way of the bladder. Extensive defects of this variety are incompatible with life, but the minor forms are sometimes seen in the adult, and may even be subjected to operation. They are fortunately very rare.

Exstrophy.—More common is a failure of development of the anterior wall of the bladder, usually seen in connection with epispadias, which is termed exstrophy of the bladder. It is nine times as frequent in males as in females. When the exstrophy is complete the pubic bones have usually failed to unite, and the bladder is spread out on the anterior wall of the abdomen, forming a shallow pouch of mucous membrane communicating below with the urethra, or directly continuous with the groove which represents it in the case of epispadias, the ureters opening in the usual position in the trigone. In the female the clitoris is also divided. Inguinal herniæ are usually present as well. In crying or straining the abdominal pressure forces the viscera through the defect in the abdominal wall, pushing before them the everted bladder as the covering of the hernia. Occasionally the lower bowel also terminates in this opening, the anus being imperforate. Exstrophy of the bladder may, however, be of lighter grade, the anterior wall being deficient only at the neck in connection with epispadias, or partially wanting above, the urethra being perfect. The condition of a patient with exstrophy is pitiable, the urine leaking constantly, and the protruded vesical mucous membrane being liable to inflammation and ulceration. When the child cries the urine can be seen to issue from the ureters in jets. The upper margin of the defect is marked by a cicatricial line, and extending upward from this towards the umbilicus is often seen a broad cicatricial area in which the recti muscles are deficient or separated.

Fig. 835.

Result of operation for exstrophy of the bladder.

Treatment.—Many operations have been suggested for this condition. One of the best is *Wood's method*, in which a flap abundantly large to cover the entire surface is cut from above, with its base at the upper border of the defect. A lateral flap is then formed on each side of the everted bladder, each flap one-half the size of the first, their bases being below at the pubes. The first flap is turned downward so that its cutaneous surface is directed towards the bladder, and sutured to the lower edge of the defect, and the lateral flaps are then slid over and united with their raw surfaces against the exposed raw surface of the upper flap. (Fig. 835.) *Maury* has practised cutting a flap from the scrotum, making a small puncture in it for the penis

to emerge through, and turning it up over the defect, but this method brings a portion of skin which is naturally covered with hair into the interior of the bladder, which is a serious defect, as the hair would become incrusted with urinary salts. *Thiersch's method* has many advocates, and consists in cutting a bridge-like lateral flap on each side, each flap being nearly large enough to cover the defect entirely. These flaps are detached from the subcutaneous tissues, and, tin foil having been slipped underneath, they are left for a week and the under surface allowed to granulate, during which the flaps shrink somewhat in size. The upper end of one bridge-flap is cut away, and the lower end of the other. The first flap is used to cover the lower part of the defect, while the other covers the upper part, the two being united transversely where their edges meet, and their granulating surfaces being turned towards the bladder. When there is wide separation of the pubic bones, Trendelenburg approximates them by dividing the sacro-iliac synchondrosis, and Passavant crowds the separated ends together without division by a broad pelvic band to which heavy weights are attached, before any attempt is made to cover in the defect. The subsequent plastic work is thus rendered simpler, as the bladder is more easily inverted. These operations must often be followed by plastic work for epispadias. If operation is impossible the treatment is limited to the protection of the parts with a hard rubber cup, which furnishes at the same time a receptacle for the urine, and is held in place by an abdominal belt or truss. This apparatus is, however, very unsatisfactory, as it is impossible to make it fit watertight.

Hernia.—The bladder is not infrequently found in hernia through the inguinal, femoral, and obturator openings, and has been wounded during operations for the radical cure of hernia. The presence of the bladder may be suspected when the size of the hernia varies with micturition, and when pressure upon it causes the desire to urinate. The prolapsed portion may consist of the intraperitoneal or extraperitoneal part of its wall, or of both. Most frequently it is found forming a part of the hernial sac, and strangulation may take place, but this accident is very rare. Examination of the bladder with a sound or distention with fluid may prove the connection between it and the hernia. The bladder may prolapse through the dilated urethra in the female and resemble a polypoid tumor in rare cases.

Diverticula.—Congenital diverticula of the bladder are occasionally met with, and the most common of these is formed by the urachus, the cavity of which extends to the umbilicus in the fœtus, but should be entirely obliterated during development, so that no trace of it remains. In infancy an indication of the situation of the urachus is very common in the rather pointed shape of the fundus of the bladder, but in the adult the latter is usually broad and flat. The urachus may remain patent throughout, so that urine is discharged at the umbilicus (some congenital obstruction of the urethra generally being present), or it may be partially patent, being obliterated at either end. Occasionally it closes at both ends and the intermediate part forms a cyst, but this is a great rarity. More commonly the vesical end closes, while the umbilical remains open, and a congenital sinus lined with epithelial tissue is formed, which is of little moment, although

some annoying mucous discharge may take place. The true congenital diverticula are usually found near the base of the bladder as small pouches, very narrow in proportion to their depth, and they seldom attain a large size. These pouches must not be confounded with the pockets which are found in the bladder as a consequence of over-distention and are formed by a hernial protrusion of the mucous membrane between the trabeculæ of the muscular coat. As they are produced by the stretching of weak places in the bladder-wall, they have a muscular layer as well as one of mucous membrane. The acquired pouches are much more common than the congenital diverticula. The opening of these pouches into the bladder may be imperfect, and urine collecting in them may decompose and excite inflammation or even abscess, and calculi may also form in them.

Treatment.—Before attempting to close a patent urachus, the urethra must be made fully sufficient for the escape of the urine. The sinus may then be treated by curetting, cauterization, or a plastic operation. It can also be extirpated by a median laparotomy, the vesical end being closed by sutures. Diverticula have in a few instances been successfully removed by an extraperitoneal laparotomy or by a sacral operation similar to Kraske's for resection of the rectum.

Injuries.—The most common injury of the bladder is rupture by a severe blow when it is in the distended condition. This injury is most frequently the result of a kick of a horse or of a man, or of a fall across a post or some article of furniture. It is most likely to occur in intoxication, because of neglect to empty the bladder and the relaxation of the abdominal muscles. An ulcerated or thinned bladder may rupture from internal pressure from retention, without external force. The distended bladder bursts from the pressure of the contained fluid under the force of the blow, and the rupture is usually situated near the fundus, although it may take place on the anterior wall, or even on the sides. The intraperitoneal ruptures outnumber the extraperitoneal in the proportion of three to one. The bladder may also be involved in stab wounds and gunshot wounds, and in cases of fracture of the pelvis the broken bone may lacerate the organ. In all these latter cases, even when there is an external wound, it is usually so small that the symptoms and treatment do not differ from those of rupture of the bladder, except in the necessity for free incision of the wound to allow of drainage.

Symptoms.—When rupture has taken place, the urine escapes into the pelvic connective tissue or into the peritoneal cavity. The bladder is empty, although no urine is passed, but when the rupture is small some urine may collect from time to time in the bladder and be evacuated. If any urine is passed it will contain blood, and blood may be evacuated even when no urine can be passed. There is pain, usually referred to the end of the penis, and there may be some vesical tenesmus. When a catheter is introduced it may withdraw urine from the cavity of the bladder, and after the flow has ceased a deeper introduction may produce a new supply of urine, the point of the instrument having penetrated the vesical wound and entered the collection of the fluid outside. The extravasated urine forms a more or less distinct tumor when the rupture is extraperitoneal, the effusion being limited by the stretched peritoneum and extending well up to Poupart's liga-

ment on both sides and above the pubes to the umbilicus. After some time the inflammation excited by the urine may cause œdema and redness of the surface. When the urine escapes into the peritoneal cavity the symptoms of a beginning peritonitis are present, but a perfectly healthy urine may be slow in exciting peritonitis, or the inflammation may be of a very low grade without definite symptoms for some days. Signs of urinary absorption, however, are present in nearly all cases, as shown by a quick hard pulse with a flushed face, and in advanced cases a typhoid condition of the tongue and of the mind. The symptoms may, however, be very obscure and even absent, for in exceptional cases the patient is able to evacuate the bladder at regular intervals, and no suspicion is entertained of a wound of that organ. The difficulty is added to by the fact that many of these patients are drunk at the time and are not aware of the injury.

Diagnosis.—This must then be made mainly by the bladder symptoms when any are present, and some assistance can be gained by passing a catheter into the organ and injecting a sterilized fluid under very low pressure. If the same amount of fluid returns as is injected, it is proof that the bladder is not injured. This test should not be made until the patient is ready for operation, because the injected fluid may spread the infection, and the incision must be made directly after its introduction. The **prognosis** of these injuries is grave in the extreme, and spontaneous cure is scarcely to be hoped for, even in the extraperitoneal rents. Suppuration takes place as far as the urine has extended, and even if the peritoneum be not involved it results in the death of the patient.

Treatment.—Free opening of the abdominal wall and exposure of the bladder is the best method of treatment. The incision should be made in the median line as if for a suprapubic lithotomy, and the peritoneum not incised, but separated from the pubes. Careful examination should then be made of the anterior wall and the sides of the bladder with a finger in the wound and a sound in the organ. If any signs of urinary extravasation are found, they should be followed down to the point of escape. When the rent is discovered a drainage-tube should be inserted through it into the bladder and the external wound packed with gauze. The cellular tissue should be broken down with the fingers as far as the urinary extravasation has extended, and secondary incisions for drainage should be made if necessary. In recent cases, when the rupture of the bladder is high up and the tissues are sound, a suture may be applied to the wound in the organ, but the external wound should be packed and kept open. If signs of peritonitis are present, or if no extraperitoneal rupture can be found, the peritoneal cavity should be opened at once and the wound sought upon that surface of the organ. If it is found, it may be sutured after Lembert's method and the peritoneal cavity then drained, after thorough irrigation, as described in speaking of suppurative peritonitis.

Foreign Bodies.—A great variety of foreign bodies have been found in the bladder, the majority having been introduced intentionally in erotic excitement or accidentally in using instruments. The most common are broken catheters, knitting-needles, hair-pins, pipe-stems, and such objects. Old rubber catheters often become brittle, and are then easily broken off.

When left for some time in the bladder they become encrusted with urinary salts and may form the nucleus of a calculus. Elongated objects usually assume a transverse position near the base. The recognition of the presence of foreign bodies is difficult. They may be demonstrated by the cystoscope, by seizing them with a lithotrite, or by exploratory cystotomy. Flexible bodies can sometimes be removed by a lithotrite, by seizing them in the centre and doubling them up as they enter the urethra. In the female they can often be removed by dilatation of the urethra, and if this fails a vaginal cystotomy should be done, as for stone. If the foreign body is rigid, a suprapubic cystotomy should be performed in the male.

Inflammation. Cystitis.—Pathology.—Cystitis, or inflammation of the bladder, is always the result of infection with germs, and may be pyogenic, gonorrhœal, or tubercular. The pyogenic form may be either catarrhal or suppurative. It is invariably due to infection, which is usually carried from without by the introduction of instruments, and only exceptionally through open wounds of the bladder or by direct extension from the kidney above or the urethra below. The infection may arise not only from the instrument itself but also from its forcing backward along the urethra some infectious discharge from that canal. The instruments are readily sterilized by the ordinary means, but it is less easy to disinfect the urethra thoroughly. Germs introduced into the healthy bladder have very little effect upon it, but if it is altered by traumatism or contains a foreign body, a stone, or blood, or even if there is retention and the urine is stagnant, infection readily takes place. These conditions are the predisposing causes of cystitis, and, unfortunately, they are almost always present in those cases which demand the introduction of instruments into the bladder. The inflammation may be limited to the neck of the bladder or may extend over its entire internal surface. In the catarrhal forms the usual changes are seen in the mucous membrane—namely, hyperæmia, increased mucous secretion, and desquamation of cells. When suppuration occurs the congestion increases, and ulceration may take place, either superficially or extending through the mucous membrane. Sometimes false membranes are formed, or, still more rarely, the lining membrane of the bladder may become detached in sheets.

Symptoms.—The cases vary much in their onset, the changes in the urine sometimes being the first indication of the inflammation, especially when the infection is slight and of a chronic type. The changes produced in the urine consist in the presence in it of mucus, epithelial cells, pus, blood, or triple phosphates, and in its greater liability to decomposition. When the inflammation is more intense, frequent or painful micturition may be the first symptom observed. Inflammation at the neck of the bladder renders the discharge of urine difficult, by the swelling of the parts and by spasmodic contraction of the sphincter. The urine is voided frequently and with effort, and occasionally even when the bladder is empty there are violent contractions, known as vesical tenesmus. Pain is present, either a dull, aching pain felt above the pubes, or, more commonly, a sharp pain referred to the end of the penis. In acute cystitis affecting the neck of the bladder the pain occurs at the end of micturition, when the contrac-

tion of the bladder exerts the greatest pressure on the tender and inflamed neck. The sufferings of a patient with acute cystitis are extreme, the constant pain in the bladder, the frequent desire to urinate, and the tenesmus depriving him of rest day and night. He may be compelled to evacuate the bladder every ten or fifteen minutes, and the act may be painful. In chronic cystitis, even when the urine is voided very frequently, the disturbance is not so great, because the pain is less. The complications of cystitis are pyelitis excited by the ascent of the infection along the ureters, and pyæmia following ulceration of the bladder, but ulceration is rare in ordinary cystitis. The sequelæ of cystitis are suppurating diverticula, atony amounting to paralysis, stone, and permanent contraction of the bladder.

Treatment.—The most effective treatment of cystitis lies in its prophylaxis. Every instrument which is introduced into the bladder must be scrupulously sterilized by boiling or by antiseptic solutions; the hands of the surgeon and the penis of the patient should also be sterilized. The urethra should be carefully cleansed by irrigation with salt solution, and a considerable quantity of water should be used for this purpose—not merely a few small syringefuls. The urethra should be gently stroked with the fingers during the irrigation, so as to dislodge any particles of pus which may be contained in the follicles. It is only by extreme precautions that cystitis can be avoided, and not always even by these. In women the entire vulva should be thoroughly cleansed before using the catheter, and the instrument should be introduced under the guidance of the eye, the fingers holding the labia so widely apart that they shall not come in contact with the catheter.

When the symptoms of cystitis are very acute, the patient should be kept in bed, with the pelvis elevated on a pillow; a milk diet with abundance of alkaline drinks should be ordered (acetate of potassium, gr. xv, in a large amount of water, every three hours), and opium given by suppositories. Occasionally injections of cocaine may be necessary to relieve the tenesmus, ten drops of a two per cent. solution being thrown into the neck of the bladder by an Ultzmann syringe. Hot applications to the perineum and hypogastric region may assist.

Local Applications.—Local treatment should, if possible, be postponed until the acute pain is relieved. It is then to be begun by irrigation of the bladder with warm mild solutions, such as Thiersch's solution one-half strength, or normal salt solution. Only two or three ounces of fluid should be allowed to enter at a time, under low pressure, but a considerable amount of fluid in all should be employed. The cause of the cystitis should be sought for and removed, especially if it be urethral stricture, prostatic hypertrophy, or vesical calculus. Very frequently these measures will effect a cure. In subacute or chronic cases more stimulating irrigations may be used, such as a solution of nitrate of silver, one-half to three grains to the pint; kreolin, one to five per cent.; potassium permanganate, one part to two thousand. The urine should be rendered neutral by the administration of alkalies if it is acid, or of benzoic acid if it is strongly alkaline. Salol is excreted with the urine, and its administration in full doses by the mouth is an excellent method of obtaining a partial sterilization of that fluid.

Copaiba, santal, buchu, and pareira may be useful. In cystitis limited to the neck of the bladder, such as is common after gonorrhœal infection, it is well to inject from one to five drops of a strong nitrate of silver solution (from five to ten grains to the ounce) by the prostatic catheter of Ultzmann when the bladder contains some urine or irrigating fluid, in order that the effect of the strong solution shall be limited strictly to the region at the tip of the catheter.

Drainage.—When irrigation fails to produce a cure, the bladder should be drained through an incision in the perineum, above the pubes, or in the vagina in the female. The perineal opening is made as in external urethrotomy, and the suprapubic as in suprapubic cystotomy. The vaginal incision is made by placing the patient in the lithotomy position, with a duck-bill speculum retracting the perineum. A sound is introduced into the bladder and turned over, so that its point is prominent in the vagina. The vaginal mucous membrane is incised upon the point of the sound in the median line just above the neck of the bladder. A long well-curved tenaculum is then made to penetrate the vesical mucous membrane at the bottom of the wound, and while it is thus steadied it is incised. The edges of the vesical and vaginal mucous membrane should be united by a few sutures around the wound, as the opening otherwise tends to contract. A large soft rubber catheter is inserted through the wound and connected with a long rubber tube passing down to a large bottle partially filled with bichloride or carbolic acid solution, so that the urine shall be delivered under the surface of the fluid, descending by the action of siphonage. The tip of the catheter should project into the bladder only just enough to permit the escape of the urine by the eye, to avoid undue irritation. Drainage of the bladder at once gives perfect rest, equalizes the circulation in the parts, and allows irrigation of the bladder to be carried out more efficiently. Drainage should be maintained until the urine becomes clear, and then the tube may be removed and the opening allowed to close. When suprapubic drainage is employed, the end of the catheter may be put into a urinal or a small bottle worn under the clothing, and the patient allowed out of bed.

Gonorrhœal cystitis is usually confined to the neck of the bladder, and has been sufficiently described in the chapter on gonorrhœa.

Tuberculosis.—Tuberculosis of the bladder often first shows itself under the guise of an acute cystitis, and suspicion is aroused only by its obstinacy. The lesions are usually in the form of ulcers, and when they are secondary to renal tuberculosis they first appear around the orifices of the ureters. The symptoms of tuberculosis may be hæmaturia, appearing without known cause, or simply frequent micturition, the urine itself being clear and with no evidence of cystitis. The diagnosis may be made by finding tubercle bacilli in the urine, or by inspection with the cystoscope or through an exploratory incision revealing tuberculous ulcers. An exploratory suprapubic incision enables the surgeon to see the interior of the bladder and to deal at once with the tuberculous lesions if present.

Treatment.—The radical treatment of tuberculosis consists in freely opening the bladder and thoroughly removing the diseased mucous membrane by the curette or scissors. The entire mucous lining of the organ

has been excised successfully in these cases, although recurrence has been the rule after a longer or shorter period of freedom, for tuberculosis of the bladder is usually secondary to similar disease of the prostate or of the kidney. The injection of iodoform in a ten per cent. emulsion with sterilized olive oil has been practised, and certainly ameliorates the symptoms, although it is doubtful if a cure can be thus obtained. Drainage of the bladder gives temporary good results, and we have seen the bladder symptoms relieved by it in one case, although the tuberculosis extended to other organs and resulted in the death of the patient a couple of years later.

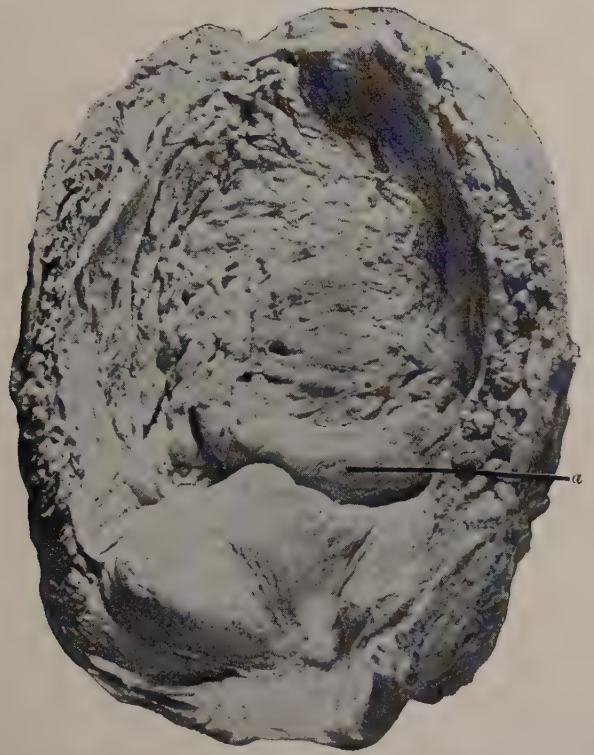
Hypertrophy of the Prostate.—The prostate properly belongs to the genital system, but its enlargement is almost without sexual symptoms, and, owing to its situation at the neck of the bladder, is of significance chiefly to the latter organ, and it will therefore be discussed in this chapter. The prostate may be enlarged by the growth of various tumors, but they are all rare except the fibromyo-adenomatous growth which is generally known as hypertrophy of the prostate.

Pathology.—The exact pathology of hypertrophy of the prostate is still a matter of dispute, some authorities claiming that the disease is simply a sequence of a general arterio-sclerosis, while others more logically compare it to fibromyoma of the uterus, an organ which is, from a biological point of view, the analogue of the prostate. The structure of these enlargements resembles that of the normal gland, but the fibromyomatous stroma is generally much more active in the production of new tissue than the glandular portion. The enlargement may be diffuse, the gland preserving its natural shape and all parts being equally hypertrophied (Fig. 836), or it may involve either one of the lateral lobes or only the middle lobe. (Fig. 837.) Sometimes pedunculated tumors project from the internal or the external surface of the gland, but this form is rarely seen except in the middle lobe. The hypertrophy of the prostate compresses the urethra passing through the organ and interferes with the evacuation of the bladder. This obstruction is greatest when the enlargement is limited to the middle lobe, as tumors in this situation are apt to project into the bladder directly over the internal meatus, and even when small they may close the urethra on the principle of a ball-and-socket valve. The enlargement of the prostate lengthens the prostatic urethra, and if it is not symmetrical it causes deviation of the canal, sometimes making it quite tortuous. The urinary obstruction is of very slow development, and is hardly noticed by the patient at first, the bladder slowly distending and its walls becoming hypertrophied. (Fig. 838.) At the same time the muscular fasciculi are apt to be separated by the great distention, and the mucous membrane protrudes between them, so that the interior view of the organ resembles a honeycomb, containing deep pockets between projecting bands. There is usually

Fig. 838.

Hypertrophy of the bladder in enlarged prostate, showing section of wall and internal surface. (Agnew.)

FIG. 836.



Hypertrophy of the median and one lateral lobe of the prostate. *a*, interureteral bar. (Watson.)

FIG. 837.

Hypertrophy of the lateral and median lobes of the prostate. (Watson.)

a thick bar between the ureteral orifices. (Fig. 102.) In rare cases the distention is uniform without the development of bands and without much hypertrophy, the wall of the bladder remaining thin. The internal pressure extends backward along the ureters, dilating them, and reaches the kidney, distending its pelvis.

Symptoms.—In the early stages the bladder is rather irritable, and constant attempts at micturition are made, but only a small quantity of urine can be passed at a time, and that with very little force and with dribbling at the close. The frequency of urination is greatest at night or early in the morning, and disturbs the patient's rest. The bladder is never completely emptied, from two to four ounces of urine being retained, and this residual urine, as it is called, constantly tends to increase in amount. In some cases the organ may be immensely distended, reaching the umbilicus, and yet the patient may be unaware of its condition because he is constantly passing small quantities of water. When thus distended the bladder-walls are paralyzed and lose very much of their contractile force, and the sphincter is also weakened, the result being a continuous flow of urine resembling the dribbling of incontinence. The condition is really one of leakage by *overflow* from the over-distention of the bladder. Occasionally there are subjective symptoms of weight in the perineum and violent and painful contractions of the bladder at the end of micturition. As a rule, however, the patient is unaware of anything serious. If infection take place in such a case and a cystitis be set up, unusually serious effects are produced on account of the retention of the urine and the impaired circulation of the bladder-wall. The retained urine readily decomposes, and this decomposition affects not merely the bladder but the kidney, and the symptoms of urethral fever are observed in typical form, beginning with or without a chill, and resembling in its course the pyæmic curve, rising very suddenly and falling as rapidly. The patient may have headache and usually nausea, the appetite is lost, the skin feels hot and dry, the tongue is apt to be coated and brown, and acute uræmia may set in with a speedily fatal result. All of these consequences may take place with very little alteration of the urine, the latter being slightly cloudy, but without pus or albumin. In other cases the general symptoms are less severe but the local signs are more acute, the urine then containing pus in large amounts, the micturition being frequent and becoming painful, especially at the end of the act. As a consequence of the cystitis and very early decomposition of the urine, triple phosphates are thrown down and phosphatic calculi are formed in the bladder, especially in the pouch behind the prostate, where the sediment collects. The sufferings of such patients are extreme, and, owing to their advanced age, the disease is apt to terminate fatally in a short time.

Local examination should be made by the finger in the rectum, which allows of accurate determination of the size, shape, and consistency of the prostate. Simultaneous pressure with the other hand above the pubes greatly assists in ascertaining the limits of the organ, and the introduction of a sound into the bladder at the same time may give additional information. The presence of a stone should always be suspected, and very careful search made for it with the sound. The quantity of *residual urine* should always be

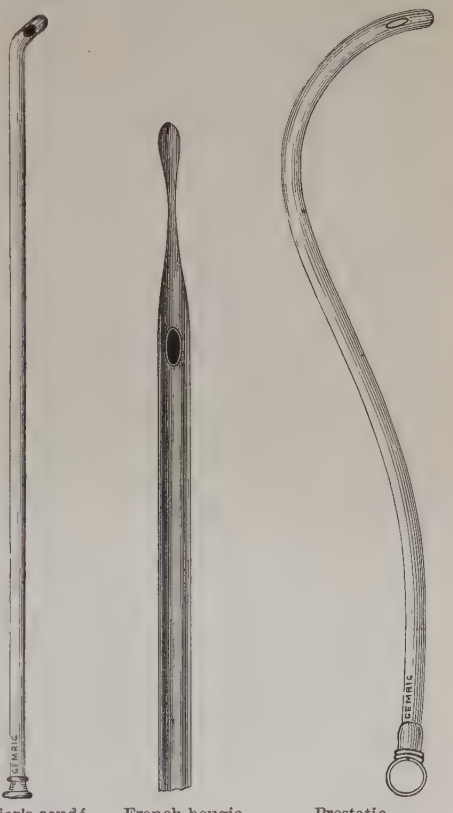
studied, especially as a tumor of the median lobe may cause obstruction even when too small to be recognized by palpation. It is measured by directing the patient to empty the bladder and then introducing a catheter and withdrawing the remainder. Over-distention of the bladder is easily recognized, as the tumor can be felt and percussed above the pubes, even if there is no "overflow."

Treatment.—Slight cases of prostatic hypertrophy in which there is no cystitis, the urine is clear, and the residual amount is only an ounce or two, and especially when the patient is disturbed only once or twice during the night to evacuate the bladder, may be treated on general principles, without any local treatment. In some cases a large part of the prostatic swelling is due to congestion, and rest in bed, with the use of cold water rectal injections, or of a double-current hollow instrument passed into the rectum so as to apply the cold continuously to the prostate, will greatly diminish the size of the gland. Rest in bed, however, in these patients, as with most old persons, is a dangerous expedient, for without the stimulus of moving about their mental power is apt to decay. Little else can be done medically, for the use of drugs, such as ergot, has been found to be without effect.

Catheterization.—The regular evacuation of the bladder by a catheter has long been a favorite method of treating prostatic hypertrophy, and for the majority of cases is still the best. If a case can be seen early, before cystitis has been established, and the daily regular use of the catheter instituted under full antiseptic precautions, the patient may soon be placed in a very comfortable position and enabled to continue his life for many years without further annoyance than the catheterization. Particular precautions in regard to cleansing the patient's penis and urethra and sterilizing the instruments and the surgeon's hands should be taken, for fear of causing decomposition of the urine and cystitis and secondary pyelitis. The catheter is to be introduced every four, six, or eight hours, according to the capacity of the bladder. If a metal instrument is employed it should have a large and long curve—the "prostatic curve." (Fig. 841.) A flexible catheter is to be preferred, and if there is difficulty in introducing it, a moderately flexible instrument, bent at the end (Mercier's *sonde coudé*, Fig. 839), or one with a narrow neck and bulb point (Fig. 840), will often pass when the ordinary catheter will not. An ordinary soft catheter provided with a rather stiff stylet curved to fit the subpubic curve can be made to tilt up at the end, and so rise over the obstruction by withdrawing the stylet for an inch or so after the instrument has been passed to the obstruction. When over-distention exists it is dangerous to evacuate the bladder completely at the first sitting, as fatal syncope has been known to occur in such cases, or acute suppression of urine, with uræmia. The latter may take place even without septic infection as a result of the sudden change in the conditions of pressure under which the renal epithelium and vessels have been working. About one-half of the urine, therefore, should be withdrawn, and normal salt solution amounting to one-quarter or one-half of that quantity should be injected and left. This is repeated at intervals of six hours, and the bladder gradually reduced in size without being subjected to the disturbance of a sudden change

of pressure. After the surgeon has established this method of treatment, and the bladder has been sufficiently "hardened" to resist slight infection, the patient should be taught to pass the catheter himself in as aseptic a manner as possible. He should be warned to be regular in its use, because a single over-distention of the bladder may cause a return of all the acute symptoms. Such patients may live in comfort for ten years or more. In some cases, indeed, this treatment results in reducing the size of the gland as soon as the bladder is regularly evacuated, by diminishing the pressure which interferes with its circulation, and the power of micturition may be almost completely regained. In cases in which the obstruction is not yet complete, the symptoms of frequent micturition and some residual urine being present, but without overflow, the use of the catheter once or twice a day to free the bladder of residual urine, with irrigation if there is a mild cystitis, is sufficient. In cases of over-distention, however, the obstruction will usually be found to be complete as soon as the increased pressure has been removed, and voluntary micturition will be impossible, at least for a long time. Sometimes considerable improvement can be obtained by simply dilating the urethra thoroughly by the passage of a large sound.

Fig. 839. Fig. 840. Fig. 841.



Mercier's coudé catheter. French bougie catheter. Prostatic catheter.

Castration, and Ligature of the Vasa Deferentia.—Attempts to reduce the size of the prostate by castration have recently been made with excellent success. In some cases, indeed, it has been reported that a patient who had not been able to pass water voluntarily for a long period of time was able to do so a few hours after the operation. It is difficult to explain such cases by any reasonable theory, the most probable being that the removal of sexual stimulus and the rest in bed have relieved the congestion of the gland and caused immediate atrophy of the epithelium and thus reduced its size. But there can be no question that a real atrophy of the gland is produced and that a permanent cure is effected by the operation. The operation in elderly persons, however, is serious, and many deaths have followed. These deaths appear to be the result of shock or of the confinement to bed, which is liable to cause hypostatic pneumonia or senile dementia.

It has been suggested simply to expose and divide both vasa deferentia after ligature under cocaine anæsthesia, thus avoiding the major operation and the necessity of keeping the patients in bed. The results of the latter operation are still on trial, but they promise to rival those of castration, in which case there is no question that it will be the better operation. Before performing either of these operations especial pains should be taken to demonstrate that there is no vesical calculus, for the serious error of removing the testicles when the symptoms were due to stone has been made in more than one instance.

Drainage.—The prostatic obstruction has been relieved by draining the bladder behind the obstruction. The opening has been made in the perineum and also above the pubes. The latter route is to be preferred, as it is easier for the patient to keep himself dry, and in some cases a sort of sphincteric action has been produced in this opening. The perineal operation is done in the ordinary manner, the urethra being opened upon a staff in the membranous portion just anterior to the ligament. Harrison inserts the drainage-tube through a trocar, which is plunged directly through the prostate from the perineum, under the guidance of a finger in the rectum. He claims that the gland often decreases in size after drainage for some weeks. The urine can be drained into a urinal secured to the legs, but the perineal opening is not very satisfactory, except while the patient is in bed. The suprapubic operation is made in the usual way in the median line close to the bone, and the wound is allowed to contract around a catheter held in place by a rubber plate which fastens around the body and has a perforation in the centre just large enough to hold the catheter. A safety-pin through the catheter keeps it at the right depth. The catheter can be closed by a clamp, which is taken off at regular intervals to allow evacuation of the bladder, and the new meatus is generally sufficiently tight around it not to leak until the bladder becomes distended. It has been suggested to make an opening into the bladder on the same principle as the Witzel method for gastrostomy, by sewing the wall of the organ in a fold over the catheter as it lies in place, and thus obtain a valvular closing of the opening, and a few cases have been reported in which a good mechanical result was obtained. In such cases the opening must be kept patent by the introduction of a catheter at least once in twenty-four hours. Patients have been enabled to resume an active life after the establishment of this suprapubic fistula, and the method is undoubtedly a good one.

Prostatectomy.—Finally, there are the radical operations in which the prostate itself is attacked. This has been done through the urethra by the internal application of an instrument like a small lithotrite, or of a galvano-caustic knife. This operation, however, is a blind proceeding, and is very liable to be followed by sepsis or severe hemorrhage. Prostatic growths which project into the bladder may also be reached by the median lithotomy wound if the surgeon have a long finger. But this procedure is also blind, for little idea of the shape and situation of the growths can be obtained, the hemorrhage is not easily controlled, and the manipulations for removing the tumor are very difficult. All these methods of reaching the growths have, therefore, fallen into disuse. The prostate may be reached by suprapubic cystotomy, or through the perineum without opening the bladder.

In the first method a large suprapubic opening is made, a rectal balloon is inserted to force the prostate up within reach of the finger, and the hypertrophied portion of the gland is removed. Wedge-shaped pieces may be excised and a channel formed for the urethra, or that canal may be relieved of pressure by incising the mucous membrane and enucleating portions of the growth with the finger-tip or blunt instruments, such as a bone rongeur. This operation is best suited for cases of hypertrophy of the median lobe, in which the tumor is frequently pedunculated, and can be easily excised by the thermo-cautery, or after ligation of its pedicle. Hemorrhage is controlled by the cautery or by pressure, and if necessary the bladder may be packed full of gauze at the end of the operation in order to maintain pressure for a long period. Drainage must be employed in every case, and if the organ is packed, the drainage-tube must be run down through the packing so as to drain off the urine from the trigonum.

The perineal method of attacking the prostate, suggested by Dittel, consists in a transverse or horseshoe-shaped incision in the perineum, described in the chapter on diseases of the prostate, by which the external surface of the prostate is exposed. Wedge-shaped pieces are excised from the enlarged lobes, and after their removal the gland tends to fall together, so that its inner surface, which interferes with the passage of the urine by projection into the urethra, falls away from that canal and the passage is made clear. Alexander exposes and incises the capsule of the prostate by a median perineal incision and inserts a finger through a suprapubic opening in the bladder. The finger in the bladder is used as a guide while portions of the gland are enucleated through the perineal wound without injuring the vesical mucous membrane.

These operations are difficult and tedious, and there is very great danger of sepsis. The patients, moreover, are old and feeble, as a rule, and do not bear even slight operations well, and hence the mortality is very high. Prostatectomy, therefore, is an operation which should be undertaken only on comparatively young individuals with a healthy bladder and in good condition otherwise. The treatment of choice is the use of the catheter, and when this is contra-indicated by a tendency to develop a severe cystitis or by the presence of advanced kidney-disease, the vasa deferentia should be ligated or the testicles removed. Prostatectomy is especially indicated for pedunculated tumors which directly obstruct the vesical exit.

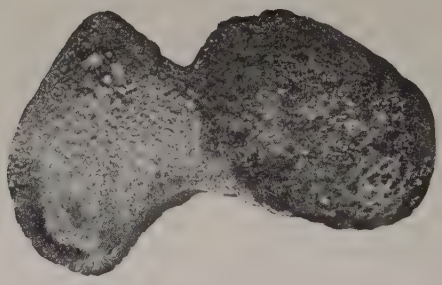
Vesical Calculus.--Stone in the bladder is most frequent at the two extremes of age, and is almost limited to the male sex. It is rare in the negro race. Its frequency in children is due to the fact that at birth the kidney contains numerous infarctions of crystallized uric acid in the urinary tubules, which are slowly washed out, and if there is any obstruction to their passage from the bladder they form a nucleus around which a stone may grow. In old age, on the other hand, the causes of calculus are usually those which excite cystitis, and the stones at this period of life are generally phosphatic on this account. In the poor calculus is most common in childhood, but in the well-to-do in old age. Every vesical calculus has a nucleus of some kind, such as a crystal of uric acid, a mass of inspissated mucus, or a small foreign body. The uric acid or the phosphatic salts are deposited in layers

around this nucleus (Fig. 842), the mass gradually increasing in size until in some cases it may fill the entire bladder. An albuminous framework holds the crystals, and therefore calculi can form only when the urine contains mucus or blood, besides being rich in salts. Calculi are most commonly formed of the urates and uric acid, the phosphatic salts, and oxalate of lime, and in that order, but rare varieties consist of such substances as cystine. The oxalate of lime calculus is very hard, and its surface usually rough from the projecting corners of

Fig. 842.

Section of a vesical calculus. (Agnew.)

Fig. 843.



Vesical calculus one end of which was encysted in a pouch.

the crystals which form the outer layer, whence it is called a mulberry calculus. The uric acid calculi are not so hard, and are smooth. Those of the urates are still softer, and the phosphatic calculi are very friable, the layers easily breaking away or even dissolving, and their surfaces are smooth. The uric acid and oxalate calculi are usually globular or egg-shaped, while the phosphatic form is often flattened. The calculi may lie for years in the bladder without symptoms, especially if they have developed in pouches in its walls or at the base behind an enlarged prostate. Occasionally they are elongated, and one end extends into one of the ureters, into the urethra, or into a vesical pouch. (Fig. 843.) Not infrequently calculi begin to grow in the prostatic sinus and then extend backward into the bladder and forward along the urethra.

Sometimes more than one calculus is found, even as many as five hundred. Calculi are of various sizes, averaging from three to six drachms in weight, and from half an inch to an inch and a half in diameter. They may weigh only a few grains or as much as six pounds. Calculi have been known to undergo spontaneous fracture in the bladder, but the causes of this accident are not understood. Multiple stones in the bladder are sometimes facetted, or show other marks of one another's presence. The presence of a calculus in the bladder causes congestion and even sloughing of the mucous membrane. If infection takes place and a cystitis is produced, its symptoms are rendered much worse by the presence of the stone.

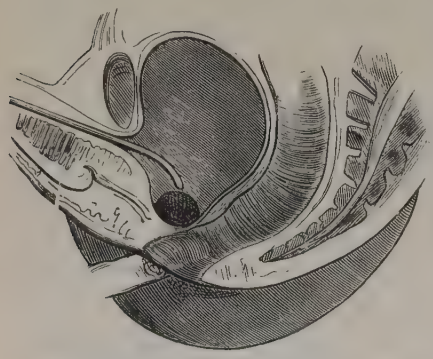
Symptoms.—The symptoms of calculus may be very severe or slight, the difference depending mainly upon the presence or absence of septic infection. If there is no cystitis the symptoms are usually slight, and in some cases the stone has existed for years without being recognized, even when of

considerable size. A small stone, however, may cause severe symptoms even without infection, by its pressure upon the sensitive neck of the bladder, or in some cases by blocking the flow of the urine, the patient observing that urination is possible only by assuming certain positions which hold the stone away from the internal meatus. The irritation of its presence may also excite the bladder to constant contraction, resulting in frequent micturition, especially during the day and while taking exercise. Blood may be passed in the urine from the contraction of the bladder over the stone at the end of micturition, crowding a rough stone against the mucous membrane. The frequent micturition and straining may cause hernia or prolapse of the rectum, especially in children. Pain is also present from the same cause, and is usually referred to the end of the penis, just below and back of the glans, although it may be felt as a dull, heavy, aching pain in the rectum, in the perineum, or above the pubes. When cystitis is present all these symptoms are greatly aggravated, and mucus and pus are found in the urine in large quantities. The pain becomes acute, and the efforts at micturition are almost constant, so that the patient has no rest day or night. On the other hand, a calculus developing as a sequel to hypertrophy of the prostate, with chronic cystitis, may cause no additional symptoms, the enlarged prostate keeping the stone away from the sensitive neck of the bladder. Children suffering from calculi may have no symptoms except frequent micturition and a habit of pulling at the foreskin, the elongation of the latter having sometimes led to the diagnosis. The symptoms, therefore, are uncertain, and the diagnosis must be made by local examination.

Diagnosis.—A cystoscopic examination will usually show the calculus at once, its character and its position. Examination with the sound will give to the skilful surgeon almost equally correct information. In making an examination by the sound or searcher the patient should lie upon the back, with a small pillow under the hips, so as to tilt the pelvis slightly backward. This facilitates the examination by rolling the stone away from the neck of the bladder, so that it can be more readily felt. The usual antiseptic precautions must be observed. The bladder should be distended with four or five ounces of fluid, and the urine may be allowed to collect to that amount, or sterilized salt solution may be injected. The instrument used for this examination is termed a searcher, and is usually a hollow metal sound or catheter with a rather short end, the tip of which is made solid. The best form is that known as Thompson's, which has a straight shaft, the tip being very short and sharply bent. The searcher having been introduced, the handle is depressed between the thighs so that the curve of the instrument shall enter the bladder, and the instrument is then pushed in as far as it will go. It is then slowly drawn forward, being given gentle rotatory movements towards one side at intervals of a quarter of an inch, exploring thoroughly one side of the bladder. In these rotatory motions the beak is made to describe an arc of about a quarter of a circle. The searcher is then pushed back again to the bottom of the bladder and again drawn forward, the rotatory motions being made on the opposite side. The handle is still further depressed between the thighs, so that the instrument may be turned completely over and the beak directed towards the base of the bladder. In this

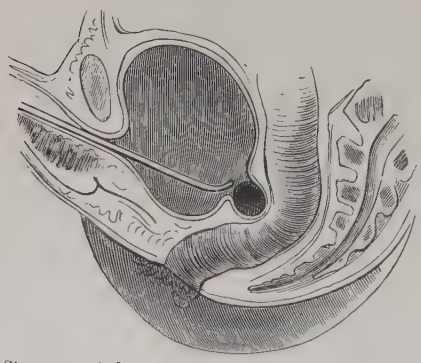
position a stone which may be lying in a pouch at the base of the bladder behind an enlarged prostate is readily detected. (Fig. 844.) Finally, the beak of the instrument is made to sweep over the surface of the bladder in all directions, to discover a stone which might be encysted in a lateral pouch. Lifting the base of the bladder by the finger in the rectum, or depressing the fundus by external pressure, is sometimes useful. If a stone is present, when the beak of the instrument touches it a sharp metallic click will be perceptible to the fingers and also to the ear. When a stone has been found, its size can be estimated by noting the points where the meatus is on the shaft when the searcher first strikes it and when it ceases to do so on being drawn forward, the distance between the two points giving its diameter. The surface of the stone is examined by passing the searcher over it to determine if it is rough or smooth. In some cases the examination is very simple, but in others even the most experienced may fail in detecting the stone. Negative evidence is of no value unless repeated examinations are made by an expert. Sometimes the use of the evacuating tube and aspirator, as in litholapaxy, will detect a small calculus which eludes the sound. A stone which is in a sac or pouch may be completely out of reach of the searcher (Figs. 845 and 846), and, on the other hand, an incrustation of the bladder-wall with phosphatic salts may resemble a calculus, and it is in such obscure cases as these that the cystoscope is most useful. An anæsthetic may

Fig. 844.



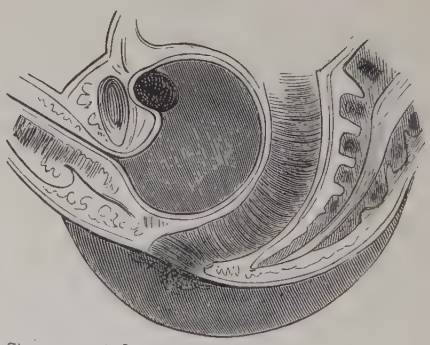
Searcher touching a stone behind the prostate, assisted by a finger inserted in the rectum. (Agnew.)

Fig. 845.



Stone encysted near base of bladder. (Agnew.)

Fig. 846.



Stone encysted near fundus of bladder. (Agnew.)

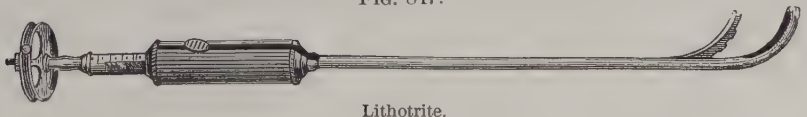
be given, or cocaine employed locally, for the examination, if the patient is very nervous or very sensitive, but in ordinary cases it will not be necessary. Occasionally a stone develops behind a urethral stricture, and the latter will need treatment before the searcher can be introduced into the bladder.

Treatment.—The medical treatment of vesical calculus is merely palliative, and no practical method of dissolving these stones by the administration of drugs has yet been discovered. The formation of uric acid stones can be avoided by careful diet, drinking an abundance of water, the administration of alkalies and salicylates, and attention to out-door exercise. Oxalate of lime calculi demand treatment for the oxaluria if it is still present. Phosphatic calculi are always secondary to some bladder condition, and are not so much affected by the general health, but we have seen them increased, if not caused, by injudicious use of alkalies to relieve the frequent micturition of an hypertrophied prostate. When operation is delayed, the treatment consists in irrigation of the bladder to correct the cystitis if any is present, rest in bed, flushing out the urinary channels with diuretic drinks, correcting acidity or alkalinity of the urine, administration of salol to render the urine aseptic, and proper attention to the general health. Anodynes may be needed for pain or to secure sleep.

The operations which are employed to remove calculi from the bladder are lithotrity or litholapaxy and lithotomy.

Lithotrity and Litholapaxy.—The old-fashioned method of lithotrity, in which the stone was broken into pieces at several sittings and allowed to pass with the urine, has been discarded for the more thorough operation introduced by Bigelow, in which the stone is crushed at once into minute pieces and evacuated at the same time by a powerful aspirating instrument. A lithotrite is an instrument devised for the crushing of a stone, and consists of a male and a female blade ending in a short beak, in which the stone is seized. The blades are continued through the shaft into the handle, where a powerful screw forces them together, with a freeing device, by which the thread of the screw can at any time be thrown out so that the two blades can slide freely by each other. The female blade is fenestrated at the beak, and the male blade, which is much smaller, plays in the fenestra, both being provided with teeth on the sides which come in contact. (Fig. 847.) The

Fig. 847.



Lithotrite.

patient should be prepared for this operation, as for lithotomy, by external sterilization and by systematic irrigation of the bladder for some days previous, to render it as aseptic as possible. The condition of the kidneys should be studied, and if nephritis is present it should be corrected as far as possible by medication and diet. The patient is placed in the same position as for the use of the searcher, the bladder is irrigated, and from four to six ounces are left in when the lithotrite is introduced. A general anæsthetic is usually to be employed, although it is possible to perform the operation with the assistance of cocaine, a four per cent. solution being introduced into the bladder, allowed to remain for five minutes, and washed out again before proceeding with the operation. The use of cocaine, however, in this manner is not entirely free from danger, and a general anæs-

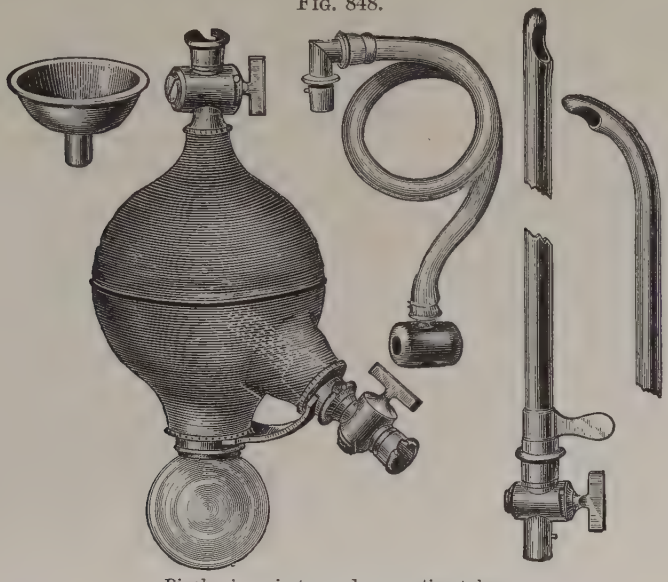
thetic is advisable whenever the patient can bear it. When nephritis is present, chloroform is preferable to ether.

Lithotrite, evacuator, and all other instruments are to be thoroughly sterilized. The lithotrite is introduced closed, the stone having previously been located with the searcher, or by using the lithotrite as a searcher. The blades are opened, a rotation of a quarter of a circle is made towards the stone, and the two jaws are slowly pushed together with great gentleness, in order to seize the stone. When the stone has been seized, firm pressure is made upon it, and the lithotrite is returned to its position with the beak turned upward as nearly as possible in the middle line, carrying the stone in its jaws. The locking device throws the screw into action, and the jaws are screwed together and the stone broken. This manipulation must be of the most gentle character from beginning to end, for the stone may fly out of the instrument and injure the bladder, or the jaws may catch the walls and wound them. It may be necessary to invert the lithotrite by depressing the handle like the searcher in order to reach a stone behind an enlarged prostate in a pocket at the base of the bladder. The first action of the lithotrite is to break the stone into two or three pieces. These pieces are seized and broken again, and so on until they are small enough to pass through the evacuating-tube. The size of the fragments is evident from the separation of the jaws of the instrument, and when the pieces have been sufficiently reduced the lithotrite is withdrawn and the evacuator introduced. The evacuator is a large metal tube very slightly curved at the end to form a beak, which has a very large opening, the edges of which are bevelled so as not to injure the urethra or bladder. To its outer extremity is attached some form of aspirator, the best being Otis's or Chismore's modification of Bigelow's original instrument. (Fig. 848.) The aspirator consists of a vessel containing sterilized salt solution and a large rubber bulb in connection with it and also containing the fluid, no air being allowed in either. The rubber bulb being squeezed by the hand, the fluid is driven into the bladder, and when the bulb is released it is drawn back again, bringing with it the fragments of the calculus, blood, mucus, and urine. These flow over the mouth of the other vessel, and the heavier particles tend to settle to the bottom, where they are retained. The bulb forces the fluid backward and forward, each aspiration bringing out fresh particles of calculus, which are added to those at the bottom of the vessel by gravity. After the small fragments are removed, those which are too large to enter the eye of the evacuator may be felt to click against it. The instrument is then withdrawn, the lithotrite introduced again, and the large fragments reduced to powder as far as possible. It may be necessary to repeat this crushing and aspiration several times in the course of the operation.

A defective lithotrite may break during the crushing, and lithotomy will then be necessary to remove the broken instrument and the stone. A very annoying accident is the jamming of the jaws of the lithotrite with the fragments of the calculus, so that they cannot be completely closed, preventing the withdrawal of the instrument, because when open it is too large to pass the urethra, for the projecting fragments of calculus would lacerate the latter. In such a case it is necessary to do a lithotomy and free

the jaws of the instrument. As a rule, however, repeated opening and closing of the jaws will clear them sufficiently to enable them to be closed. The after treatment of these cases consists of frequent irrigation of the blad-

Fig. 848.



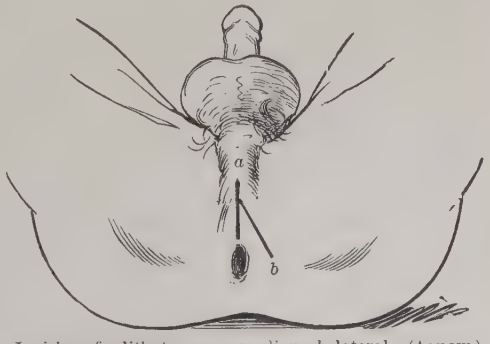
Bigelow's aspirator and evacuating tubes.

der and watching and treating the renal complications. The patient should be got out of bed at the earliest possible moment.

Litholapaxy has of late been strongly advocated for children and infants, for although the operation is particularly difficult, because of the small size of the urethra, with instruments of proper size (12 to 18 French) excellent results have been obtained. The Anglo-Indian surgeons have operated on many hundreds of young children with a mortality of only from one to three per cent.

Lithotomy.—The bladder may be opened in the perineum or above the pubes. Formerly the perineal operations were preferred: they are of two kinds—the median and the lateral.

Fig. 849.



Incisions for lithotomy: *a*, median; *b*, lateral. (Agnew.)

Median Lithotomy.—In the median operation the patient is placed upon the back, with the thighs flexed upon the abdomen, and a sound with a groove upon its lower surface, called a staff, is introduced into the bladder. The staff being in place and the operator seated facing the perineum, with his left index finger in the rectum, he incises the perineum in the median line (Fig. 849, *a*), just anterior to the sphincter, and then inserts the point of the knife into the groove of the

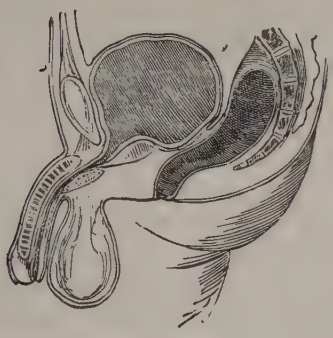
staff and makes an opening in the floor of the urethra. A long narrow knife is then slipped along the groove into the bladder, and made to enlarge the incision on withdrawal by cutting towards the rectum, which is held out of the way by the finger. A director is then passed into the bladder, the staff withdrawn, and a silver catheter passed through the wound into the bladder to prove that that organ has been reached. The finger is then inserted in the wound, dilating the opening, and the stone felt in the bladder. A pair of forceps slightly curved, with broad spoon-like ends, is slipped along the finger, or inserted after its withdrawal if the wound is too small, and made to grasp the stone, the same gentleness being used in seizing the calculus as in litholapaxy. The stone is then withdrawn by the forceps, which are given rotatory and lever-like movements to facilitate its extraction. When the stone has been removed, a soft rubber catheter should be inserted, the bladder thoroughly irrigated until the fluid returns clear, and the catheter left in place for drainage. The wound just admits the finger, and a stone larger than this cannot be removed by this operation unless it is broken into fragments.

Lateral Lithotomy.—In the operation of lateral lithotomy a staff is used which has its groove upon the side towards the patient's left. The surgeon makes an incision in the perineum (Fig. 849, *b*), beginning at the raphe in the central point of the perineum, about an inch and a quarter in front of the anus in the adult, and directed obliquely backward and outward so as to open the ischio-rectal space. This incision is deepened until the urethra is reached, which is exposed somewhat on the side. The point of a long narrow knife is made to puncture the wall of the urethra and enter the groove on the staff, and is slipped into the bladder along the groove dividing the urethra on the left-hand side. As the knife is withdrawn the handle is dropped a little, so that the blade cuts a little deeper through the outer tissues. The operator's finger is placed in the rectum before opening the urethra, as in the previous operation, to avoid injury to the former organ. The knife as it passes into the bladder cuts into the left lobe of the prostate, and the wound can, therefore, be made much larger than that of a median lithotomy. The succeeding steps are the same as in the other case, but a larger stone may be removed, because the edges of the incision through the prostate can be allowed to stretch and tear, the only limit to the extent of the wound in this direction being the capsule of the prostate, which must not be injured, for fear of urinary extravasation. Peritonitis has also followed in such cases. The lateral operation involves the danger of injury to the left seminal vesicle and duct, as well as to the rectum, but permanent injury to the sexual organs seems to be rare. A recto-vesical or recto-urethral fistula may be the result of injury to the rectum.

Suprapubic Lithotomy.—Finally, we come to the old operation recently revived, opening the bladder above the pubes. The introduction of aseptic measures has almost removed the dangers of urinary infiltration or peritonitis, and the method gives free access to the bladder, where the surgeon can see what he is doing and remove a stone of any size. For the performance of this operation it is advantageous to place the patient in the Trendelenburg position. The bladder is then irrigated and moderately distended with fluid, the quantity of which will vary according to the condition

of the bladder, and no great force should be employed in its introduction, as a rupture might easily occur. Sometimes the bladder is so contracted that it will hold only two or three ounces, and in other cases eight or ten may be injected with impunity. The pressure should never be over that of a column of water six feet high, for rupture of the bladder has followed the injection. The distention of the bladder pushes upward the peritoneal fold in front of that organ (Figs. 850 and 851), uncovering a space on its

Fig. 850.



Section of male pelvis, showing normal relations of peritoneum and bladder. (Hunt.)

Fig. 851.

Same, with rectum and bladder distended. (Hunt.)

anterior surface from one-half an inch to an inch above the pubes, which may be still further increased by inserting a rubber balloon, known as Petersen's balloon, in the rectum, and distending it with water or air. A maximum of exposure is obtained by injecting about eight ounces of fluid in the bag and five or six ounces in the bladder itself. The rectal balloon, however, has been known to cause injury to that organ by over-distention and even rupture, and the introduction of Trendelenburg's position has led the majority of surgeons to dispense with its use, except in cases where it is advisable to have the base of the bladder lifted up so as to be more accessible. Some surgeons have even abandoned distention of the bladder, but if the peritoneum is unusually adherent to the bladder owing to long-standing inflammation of the organ, it is difficult to detach it, and the neglect of distention certainly adds to the risk of the operation. Some prefer to use air instead of water for distending the bladder.

A median incision is made upward from the pubic bone two or three inches in length. This incision is deepened until the abdominal wall is cut through. The index finger is then passed into the prevesical space, keeping close to the pubes, and all the loose tissue in front of the bladder, including the peritoneal fold, is drawn well upward. The peritoneum is, as a rule, easily seen and detached by the finger until a space of an inch or more of the anterior wall of the bladder lies exposed in the wound. With a curved needle two loops of strong silk are passed through the bladder-walls, a little on each side of the median line, to use as retractors. The bladder is then incised between the loops, avoiding any conspicuous veins. The incision should be only large enough to admit the finger at first, and the

finger should be inserted at once, before the contained fluid has escaped. Exploration then determines the presence of the stone and the condition of the bladder, and if the size of the stone requires a larger wound the opening is enlarged downward and forward with the scissors. If necessary, this incision may be carried down behind the pubes almost to the neck of the bladder. Forceps are introduced and the stone is withdrawn, and if there is any difficulty in removing it the incision should be enlarged with the scissors rather than lacerated by the stone itself. The interior of the bladder is thoroughly irrigated, and the operation finished by inserting a drainage-tube and packing the wound or by suturing the wound in the bladder. In the first case a drainage-tube half an inch in diameter, having lateral openings near its lower end, or a large rubber catheter, is placed so as to reach to the base of the bladder. The edges of the bladder wound are held together around the tube by the silk threads passed previously, and iodoform gauze is packed into the connective tissue between the bladder and the pubes in front and the abdominal wall on both sides. A dressing is applied around the tube, which is connected with a siphon-tube at the side of the bed. A more powerful suction apparatus can be formed by hanging an irrigator above the bed and connecting it with an S-tube or simply with a rubber tube tied in a loop so as to form a sort of trap, from which the tube passes to the T-tube, one end of which is connected with the catheter, and so descends to the vessel beneath the bed. The constant flow of fluid from the irrigator through the S and T tubes makes a suction apparatus on the principle of the air-pump, and constantly draws fluid from the bladder. This method has, however, the disadvantage that the suction is usually so powerful that it draws the wall of the bladder into the eye of the catheter and causes pain and interruption to the flow of the urine. The ordinary siphon drainage is usually sufficient.

Drainage of the bladder is the method of choice when that organ is extensively diseased or when there is considerable hemorrhage from its interior. When the bladder is comparatively healthy and there is no hemorrhage, the wound may be sutured, and in any case a large wound should be partially closed by sutures, leaving an opening only large enough for the drainage-tube. These sutures must be of fine silk or fine catgut, and should not penetrate the interior of the organ, as they might form the nucleus of a calculous deposit. The sutures are therefore passed in the Lembert fashion, bringing together the muscular layers of the bladder, but not penetrating the mucous membrane, and being placed about an eighth of an inch apart. A second tier of sutures is placed over these, drawing up the wall of the bladder in a fold and covering in the first tier completely. The tightness of these sutures may be tested by injecting water. After a thorough washing, a light packing is then placed in the external wound, unless it is very large, when it may be somewhat reduced by sutures; but it is unwise to suture it entirely, because suppuration and urinary infiltration may take place if the sutures in the bladder should yield. Some surgeons leave a catheter in the urethra and drain off the urine during the healing of the wound, others have the urine drawn by catheter at regular intervals, and still others allow the patient to urinate naturally.

The after-treatment of litholapaxy and lithotomy consists in rest in bed, thorough irrigation of the bladder two or three times daily, light diet, and diuretics if there is any sign of nephritis. It is useful to administer salol in moderate doses to keep the urine aseptic.

Choice of Operation.—The choice of these different methods of treatment depends upon the experience of the surgeon, the character of the stone, and the local conditions. Litholapaxy does not confine the patient to bed for so long a period as lithotomy, but requires special experience on the part of the surgeon, and the prolonged operation is a source of danger to an enfeebled patient, for it often lasts two or three hours. Chismore has sought to avoid these dangers by using cocaine, crushing the stone a few times, removing whatever can be obtained by the evacuator, and repeating the operation in a few days. He does not put his patients to bed. Litholapaxy does not as surely guard against a recurrence of the stone as lithotomy, for a fragment may be left in the bladder, which will form the nucleus of another stone. It also fails to provide direct drainage for the inflamed bladder. Litholapaxy should not be attempted if the stone is very hard or large or encysted, or if there is a foul cystitis which requires drainage, or an enlarged prostate which might be treated by operation. A well-marked nephritis is also a counter-indication. For all other cases it is probably the best method.

Lithotomy is indicated in the cases not suitable for litholapaxy, although the recent improvements in the suprapubic operation bid fair to make it the rival of the method by crushing in all cases. The other operations are now seldom employed, the median on account of the small size of the opening, and the lateral on account of the danger of wounding the rectum or the seminal duct. The bladder is efficiently drained by the suprapubic incision, but some surgeons prefer to add a small perineal incision for drainage in bad cases. To lessen the danger of urinary infiltration, Senn advises doing the suprapubic section in two stages, exposing the bladder at a preliminary operation, and incising it several days later, when the external wound is granulating.

Stone in the Female Bladder.—In the female, small stones may be removed by dilatation of the urethra with the finger, an enlargement of that canal sufficient to admit the forefinger being possible without permanent paralysis. Larger stones must be removed by litholapaxy or incision. The crushing operation is usually easy, because the stone can often be directed into the grasp of the instrument by the finger introduced into the vagina, and the wide, short urethra allows very large and powerful instruments to be employed. It will often be necessary to compress the urethra around the instruments in order to retain the fluid in the bladder. Cystotomy may be either vaginal or suprapubic. The vaginal incision is made in the median line upon a sound introduced into the bladder, the beak of the sound being turned downward as soon as it passes into the neck of the bladder, and an incision made upon it through the vaginal wall. The opening may be closed at once by sutures when the calculus has been removed, inserted as in an operation for vesico-vaginal fistula, and primary union is generally obtained. In a child it may be necessary to incise the

perineum to extract the stone. A suprapubic operation will seldom be necessary in the female, except in young children, and is performed in the same manner as in the male.

Tumors of the Bladder.—Various tumors grow in the bladder, the most common being the papillomata and the malignant neoplasms, especially carcinoma. The villous or dendritic form of papilloma consists of masses of slender long papillæ, sometimes two or three inches in length, each containing a blood-vessel covered by a single layer of epithelium and floating free in the urine. In the fibrous form the papillæ have a solid fibrous stroma, and are thicker and shorter. A myxomatous variety has also been observed. The base of the papilloma is occasionally quite thick and fibrous, and a carcinomatous change not infrequently takes place in this part. Primary carcinoma of the bladder may be epithelioma or glandular carcinoma. It often develops at the base of the papilloma, but may originate independently in the form of a superficial ulcer which gradually eats into the wall, where the neoplasm may form masses of considerable size beneath the base of the ulcer. The bladder is more frequently involved by carcinoma of neighboring organs. Sarcoma develops in the thickness of the vesical wall, and is at first covered with normal mucous membrane, but the latter afterwards ulcerates, and the tumors are then difficult to distinguish from carcinoma, although they are not usually so hard to the touch.

Symptoms.—The symptoms of tumor of the bladder are nearly the same whatever its nature, consisting in frequent micturition, bloody urine, and, if infection takes place, a cystitis of a peculiarly intense and obstinate type. The micturition in these cases is usually free unless the growth is at the neck of the bladder and plugs the orifice. The frequency is greatest in the daytime, and ceases to trouble the patient at night, thus differing from that due to prostatic obstruction. The blood is bright blood, and usually follows at the end of micturition, being squeezed from the tumor by the final contraction. It may, however, be equally diffused in the urine, and clots are sometimes found. There may be long intervals without hæmaturia. The patient becomes exhausted by the disturbance of his rest and by the loss of blood, and is usually very anæmic. Pain is an uncertain and late symptom. If infection is set up by septic instruments there is likely to be some elevation of temperature from the sloughing masses of the tumor. Fragments of the tumor are occasionally passed, especially after an examination by the sound. In rare instances long papillomatous growths or polypoid excrescences from a carcinoma have extended down the urethra, and even appeared at the meatus. In such cases there is considerable obstruction to the passage of the urine and to the introduction of instruments.

Diagnosis.—The diagnosis of tumor of the bladder is made by excluding the presence of stone by examination with the searcher, and the searcher may in some cases detect a projecting mass upon the side of the bladder or between the instrument in the bladder and the finger in the rectum. In advanced cases of malignant disease rectal examination will show infiltration of the base of the bladder and surrounding parts; in women digital examination can be made through the dilated urethra. A parasite known as **Distoma hæmatobium**, which is found in certain countries, such as Egypt

and Southern Africa, becomes lodged in the renal vessels and discharges its eggs into the kidney, whence they make their way downward into the bladder and cause irritation of that organ and patches of indurated granulations resembling sarcoma, which bleed very freely. The symptoms resemble those of cystitis or tumor. This condition is exceedingly difficult to distinguish from a tumor of the bladder, although the eggs may be found in the urine; but the disease is very rare in this country, being found only in those who have lived where it is endemic. The use of the cystoscope will, as a rule, enable the surgeon to determine not only the presence of a tumor, but its size, and this examination should never be omitted, although it is unsatisfactory if there is much bleeding. In cases of doubt an exploratory incision should be made through the perineum or above the pubes. The introduction of the suprapubic method has thrown the perineal incision into discredit, for it is only with a very long finger that the tumors can be reached, and the operator necessarily works in the dark.

Prognosis.—The prognosis of tumors of the bladder is bad, as even the benign growths cause death by the severe hemorrhage, although they may have a very slow course. The hæmaturia and necessary instrumentation are likely to result in cystitis and pyelitis. Malignant tumors produce death in from eighteen months to three years after the first symptoms. The papillomata can be cured by operation, but not the malignant tumors, because the diagnosis of the latter can seldom be made sufficiently early.

Treatment.—Operation is the only possible treatment for these tumors, and suprapubic cystotomy is the best method of reaching them. The patient should be prepared for operation as usual, the rectal balloon inserted and the bladder distended and opened by the suprapubic incision. The tumor can then be thoroughly examined with the finger and the eye, and removed at once if removal is possible. Papillomatous growths may be removed and the base thoroughly destroyed with the curette, thermocautery, or curved scissors. Other tumors may be excised, provided that they are not so extensive as to render all attempts at a radical cure hopeless. Large portions of the wall of the bladder have been successfully removed. When the tumor cannot be removed, the wound should be left open for drainage, and the patient's sufferings are greatly relieved by this treatment, although it involves some danger of infection resulting in cystitis or pyelitis. Hemorrhage from the interior of the bladder can be controlled by a gauze tampon, but the pressure of the gauze, and especially its removal, is apt to be painful, and packing should be avoided if possible. In any case the bladder should be drained through the wound, the urethra, or a small perineal incision made for the purpose.

Cystoscopy.—Cystoscopy is the examination of the bladder with the eye by instruments introduced through the urethra. It is most easily accomplished in the female by means of *Kelly's method.* This consists in dilatation of the urethra to a diameter of twelve to fifteen millimetres and the introduction of short cylindrical specula, the patient being placed in the lithotomy position with extreme elevation of the pelvis. The contents of the abdomen then fall away from the pelvis and air enters the bladder

by the speculum, fully distending that organ. The urine is withdrawn by a tube with a suction bulb, and then the greater part of the interior of the bladder can be illuminated by a forehead mirror and easily inspected. The mouths of the ureters can be seen and bougies or catheters readily inserted for exploration or to collect the urine. General anæsthesia is advisable, although not essential.

The *Nitze-Leiter cystoscope* can be used in either sex, and consists of a hollow tube bent at an obtuse angle at the end, forming a short beak. At the point of the instrument is fixed a small incandescent electric light, the wires of which run through the shaft of the instrument, and at the angle is situated a glass prism which receives the rays of light coming from the illuminated bladder and reflects them up the shaft of the instrument to pass through a system of lenses which admit of accurate focussing. The bladder is filled with sterilized normal salt solution, the instrument lubricated with glycerin and introduced, the current turned on, and the observer then studies the interior of the bladder through the lenses. If there is much bleeding from the interior of the bladder the period of observation will be short, as the instrument must be withdrawn and the bladder washed out. A similar instrument has been invented by *Caspar*, which contains a groove on one side of the shaft through which a fine bougie can be passed, the end of which turns up at the beak of the instrument into the field of vision. The mouth of the ureter can be found by the surgeon, and the bougie then projected into the field of vision and guided directly into the opening. It can then be detached from the shaft of the instrument and passed as far as necessary into the ureter, and the urine from the kidney of that side collected for examination. Even without this instrument the cystoscope gives valuable information as to the quantity of urine passed relatively by the two kidneys, and also whether it contains pus or blood, as the urine can be seen flowing from the ureter.

Neuroses.—The cases formerly considered **neuralgia** of the bladder have been gradually distributed under the different lesions which cause the pain as our means of diagnosis have improved, and the affection is no longer recognized as an independent disease except in rare cases.

Spasm may occur either in the detrusor or in the sphincter muscles, and occasionally in both at once. Spasm of the muscles of the vesical wall is usually known as tenesmus, and is the result of intense irritation of the mucous membrane by inflammation, by the presence of a calculus, a foreign body, or a parasite, or by certain drugs, such as cantharides. The patient is constantly passing small quantities of water, and the bladder is kept empty, unless spasmodic contraction of the sphincter is also present, when there may be retention. There is great pain in the pelvis running down to the glans penis. Spasm of the sphincter alone is marked by retention of urine, and the contraction may be so close as to prevent the introduction of a filiform bougie. Pain is present only when efforts are made to evacuate the bladder. **Treatment** consists in thorough stretching of the sphincter by the passage of large sounds, but the cause of the spasm should be first sought for and removed. Opiates are useful for tenesmus, especially a suppository of opium and belladonna, āā gr. ss to gr. i.

Paralysis may attack either the detrusor or the sphincter, paralysis of the former resulting in retention and paralysis of the latter in incontinence of urine. Both muscles may also be involved at once, the abdominal pressure then causing the urine to dribble away. Paralytic retention is found in injuries and diseases of the spinal cord at any point, and paralytic incontinence only when the lower lumbar region is involved. The former may also be the result of voluntary over-distention from enforced holding of the urine and of long-continued over-distention due to mechanical obstruction. Muscular power always returns after a few catheterizations in the first case, and sometimes in the second. Sphincteric paralysis may be the result of over-distention by the finger or by instruments, especially in the female. The sphincter may also be congenitally deficient. **Treatment** consists in the removal of the cause of paralysis, and the use of the catheter for retention. Electricity may be applied locally and to the lumbar plexus in order to restore power to the sphincter. Especial pains must be taken in maintaining asepsis in all instrumentation during paralytic retention, as the danger of infection is much greater than in the normal bladder. Paralytic incontinence demands the wearing of a urinal when the patient is up, and careful nursing to keep him dry when in bed.

Functional disturbances of micturition are exceedingly common, and are usually the result of disturbed mental states in nervous individuals. Retention and irritability of the bladder, the latter sometimes amounting to complete incontinence, are both caused by hysteria, or by emotional disturbances, such as fright or anxiety, and are also seen after certain operations about the pelvis, especially those for hemorrhoids. The fact that many persons are unable to pass water while lying down or in the presence of others is well known. Sometimes there appears to be a lack of coördination between the detrusor and sphincter muscles, resulting in a feeble or intermittent stream—a condition well named "stammering of the bladder."

Enuresis.—In children the urine is often passed during sleep, and this is sometimes observed in adults who are epileptic, or during anæsthesia, the cause being the suspension of sensation which should awaken the voluntary contraction of the sphincter when the urine begins to enter the urethra. A careful examination should be made of the genitals and bladder and the urine, as the incontinence may be a symptom of vesical calculus or other disease, or may be caused by a long foreskin or a narrow meatus.

Treatment.—Nervous retention can sometimes be overcome by mental effort, by distracting the attention, by placing cold or wet cloths on the wrists or abdomen, or by making water run noisily from a faucet near by. The catheter will often be necessary. Nocturnal incontinence, or rather enuresis, in children, may be cured by circumcision or by education, but punishment is apt to increase the difficulty. It is well to make the child sleep on the side, with light covering, in a cool room, and not immediately after a heavy meal. Good results have been claimed for elevation of the foot of the bed, on the theory that it removes some of the weight of the urine from the neck of the bladder. An old-established method sometimes useful is the administration of belladonna to the limit of tolerance.

INJURIES AND SURGICAL DISEASES OF THE KIDNEY.

Injuries.—The kidney may be lacerated and its capsule ruptured by a severe contusion of the abdomen or loins, or it may be wounded by penetrating objects, as in stab or gunshot wounds. Slight contusions cause pain and local tenderness, and sometimes a transient hæmaturia. Severer injuries cause marked hæmaturia, sometimes with attacks of renal colic from blocking of the ureter by clots. When the capsule is ruptured the urine may escape and cause perinephritic abscesses or peritonitis, according to the situation of the rupture, but the signs of urinary extravasation and inflammation do not usually appear for three or four days. Penetrating wounds are followed by free hemorrhage, and later by an escape of urine, and, unless the wound be a very open one, urinary extravasation and inflammation of the surrounding tissues will occur. The treatment of the slight injuries consists in rest in bed, and washing out of the bladder if there is a tendency for clots to accumulate in it. If there is severe hemorrhage, the kidney should be exposed and the laceration closed by sutures in order to arrest it, or, if this is impracticable, the organ should be removed. Nephrectomy is also indicated when the kidney is severely crushed or lacerated, and especially if there is a liability of peritonitis from an anterior rent in the capsule. The most dangerous cases are those with internal hemorrhage and extravasation of urine, without much bleeding into the bladder. Urinary infiltration and abscess should be treated by free incision, and small punctured wounds should be sufficiently enlarged to afford good drainage.

Anomalies.—One kidney may be very small and atrophied, or even entirely absent. In some cases there is but a single kidney, which occupies the middle line, and is made up of the two kidneys, more or less fused together or connected by a transverse bar of kidney-substance, and often assuming the shape of a horseshoe.

Floating and Movable Kidney.—Anomalies in the position of the kidney are exceedingly frequent, and they are nearly all brought about by relaxation of the peritoneal ligaments which hold the organ in place, and which may become so lax as to form a mesonephron and allow the kidney to move to all parts of the abdomen, for the kidney has been found in the pelvis and even in an inguinal hernial sac. The term floating kidney is reserved for cases in which there is a true mesonephron, those in which the kidney has only abnormal mobility behind the peritoneum being called movable kidney. A true floating kidney is a congenital abnormality. Descent of the kidney is favored by absorption of fat in stout persons, and may follow severe muscular efforts, such as lifting heavy weights. The displacement is seven times more common in women than in men, perhaps on account of the abdominal changes caused by pregnancy, and it is more frequent on the right side. In estimating the amount of displacement it should be noted that the right kidney naturally lies a little lower than the left, owing to the bulk of the liver, and that in patients with a relaxed abdomen the lower end of the normal kidney can be felt for about one-third of its long diameter. If the entire kidney can be palpated, it may usually be considered pathologically movable.

Symptoms.—The symptoms are by no means proportionate to the amount of mobility. A congenital floating kidney may be discovered accidentally in any part of the abdomen, having never given rise to any evil effects. On the other hand, even a slight displacement of the kidney, amounting to only one-half its long diameter, may cause very characteristic symptoms, because the ligaments drag upon the duodenum. These symptoms are nausea, a tendency to vomiting, and distress in the stomach, with some nervous disturbance, and occasionally pain in the back and weakness on exertion. The stomach may be dilated. A floating kidney may cause various symptoms by interfering with the function of other organs by its pressure, especially if it descends into the pelvis. If the pedicle becomes twisted, the ureter will be compressed and the flow of urine interrupted, the retention of the latter being indicated by severe pain on that side, the tumor formed by the distended kidney, and a diminished quantity of urine. There may be distention of the intestine in the neighborhood of the affected kidney. The attack usually passes off if the kidney is pushed back in place and the patient kept in bed. The diagnosis between these attacks and impaction of gall-stones with dilated gall-bladder may be very difficult. A floating kidney is subject to all the diseases of the normal kidney, and, owing to the tendency of its displacement to disturb the circulation and the escape of urine, the symptoms are often more severe.

Treatment.—The treatment of a movable kidney consists in the first place in the application of a broad binder, with a large, somewhat wedge-shaped pad which presses in under the ribs and supports the organ. Before the pad is applied it is well to have the patient remain in bed on his back for some days, in order to allow the kidney to settle back into its proper position. If this treatment fails, the operation of nephrorrhaphy may be performed.

Inflammations.—When inflammation attacks the glandular portion of the organ it is called nephritis, and when it is confined to the pelvis it is termed pyelitis. Pyonephrosis is a suppurative inflammation of the pelvis of the kidney with blocking of the ureters, converting the kidney into a pus-sac. Pyonephrosis may result from infection of a hydro-nephrosis. Suppurative inflammation of the kidney is the only form which comes under surgical treatment.

Renal suppuration may be caused by infection, which travels up the ureter from the bladder, or may reach the organ by way of the blood-vessels. Bacteria are excreted by the kidney with the urine, and, as we have already seen, may occasionally be thrown out without damage to the organ, but usually they form foci of infection. The ordinary pyæmic embolism may occur in the kidney and result in multiple metastatic abscesses. The kidney may also be attacked by gonorrhœal infection ascending through the bladder. Tuberculous infection may take place by the same route or through the blood-vessels. Metastatic abscesses of the kidney are usually multiple, of small size, and occur in both kidneys, so that they are not amenable to treatment. Metastatic abscesses are occasionally single or few in number, and may result in pyonephrosis. An abscess of the kidney may penetrate into the pelvis of the organ, may rupture into the cellular tissue around it, or may perforate the peritoneum and give rise to peritonitis.

Symptoms.—The symptoms of renal suppuration will depend upon the cause of the inflammation. When there is a renal calculus some pyogenic infection must take place in order to produce the suppuration. In such cases there will be the previous symptoms of stone, such as hæmaturia and pain in the kidney, increased by motion, and to them will be added the signs of acute inflammation, such as fever, with possibly a chill and the appearance of pus in the urine. The metastatic abscesses usually run a course without symptoms except an irregular elevation of temperature and possibly a chill occurring with the development of a fresh pyæmic focus. The local symptoms of suppuration in the kidney are pain in the loins and tenderness over the affected organ, which is easily detected by passing the hand under the loin as the patient lies upon the back and giving a sharp upward movement with the fingers. The organ may be enlarged perceptibly, but this is more likely to be the case in pyonephrosis than in abscess of the kidney-substance. The urine will be diminished in quantity, will have a high specific gravity, and will sometimes contain albumin in considerable quantities. There are usually no casts, but pus or blood will appear if the abscess has penetrated the pelvis. The general symptoms of the condition are fever, with or without a chill, and uræmic symptoms. The suppuration may follow a cystitis, whether pyogenic or gonorrhœal in origin, and is frequent from infection after operations on the urinary organs, whence the name *surgical kidney* given to the condition.

Pyelitis.—Pyelitis is an inflammation limited to the pelvis of the kidney, shown by desquamation of its epithelial lining, the peculiar caudate cells appearing in the urine, sometimes arranged in layers, accompanied by conical plugs of pus-cells discharged from the mouths of the urinary tubules. When infection of the kidney takes place from below, pyelitis will generally precede suppuration in the kidney-substance, and is, indeed, the lesion usually known under the name of surgical kidney. In the acute form of pyelitis the symptoms are similar to those described above. In the chronic form there may be little sign of the disease except in the urine, which is acid and contains large amounts of albumin with the characteristic epithelium of the pelvis and the groups of pus-cells just described, but without casts. In many cases, however, the epithelium has not the characteristic caudate appearance, and there is also danger of mistaking kite-shaped epithelium from the deeper layers of the bladder for the pelvic cells. The general disturbance set up by chronic pyelitis is usually slight, although there may be a little hectic fever, and anæmia is marked. The inflammation may or may not be accompanied by pain or tenderness.

Pyonephrosis.—By pyonephrosis is meant a condition of distention of the pelvis and of the kidney, which may be converted into a thin sac filled with pus. It occurs in suppurative inflammation when there is obstruction of the ureter. The symptoms do not differ from those of pyelitis, as pyonephrosis is often an advanced stage of that affection, but the kidney forms a large tumor. The obstruction to the ureter may be complete, partial, or intermittent. In the first case no urine from the diseased kidney can enter the bladder, and if that organ and the other kidney be healthy the urine will be normal. In the majority of cases the obstruction

is not complete, and some purulent urine is discharged. Sometimes the obstruction is intermittent, and if the other kidney be healthy there will be alternating periods of clear and cloudy urine, according as the secretion of the diseased organ is shut off or discharged into the bladder. The prognosis of abscess of the kidney is very bad, as is also that of suppurative pyelitis originating from an abscess of the kidney or from an ascending infection.

Treatment.—In a simple pyelitis of a catarrhal or mildly suppurative type it will probably be sufficient to remove the cause, such as a calculus in the pelvis or a suppurative condition of the bladder. Prophylaxis is most important, and is to be effected by observing strict asepsis in all operative measures upon the bladder, including the ordinary use of the catheter, and by instituting irrigation of that organ at the first indication of renal difficulty, such as a rise of temperature or local tenderness. Now that catheterization of the ureters in the female is easily performed by Kelly's method, it will probably be possible to treat cases of mild pyelitis by introducing the catheter into the pelvis of the kidney and irrigating that cavity. This has already been done successfully through a vesico-vaginal fistula. In the male the same may possibly be accomplished in the future with the aid of the cystoscope. When suppuration beginning as a pyelitis has extended to the kidney-tissue, or a pyonephrosis has formed, the suppurating cavity may be drained by an external incision or nephrotomy, which should be made through the substance of the kidney, and not through the pelvis, in order to give it the best opportunity to contract later. These cases, however, often result in a permanent fistula, which is a source of annoyance and danger to the patient, and therefore nephrectomy is preferable when the other kidney is sound. Drainage is particularly suitable for those cases in which the kidney-substance is not disorganized, but merely distended around the pelvis containing the pus. Even when the kidney is completely disorganized it should not be removed if the patient is in bad condition or if the pyonephrosis is very large and adherent to the surrounding parts so that the operation will present unusual difficulty. Nephrotomy, followed by nephrectomy when the patient has recovered his strength, is the safer procedure in such cases. Abscesses which have formed in the kidney-tissue may be treated by nephrotomy and drainage, if it is possible to make a diagnosis before the pelvis is involved; after that time they must be treated on the same principles as pyonephrosis of ordinary origin. In metastatic suppuration of the kidney it is seldom possible to relieve the patient by surgical means, but we have obtained a cure in one case by nephrotomy and drainage. The large number of abscesses in the kidney in these cases will often make thorough drainage impracticable, and if the other kidney could be proved to be sound nephrectomy would be preferable, but such proof will seldom be forthcoming.

Perinephritis.—Suppurative perinephritis is a suppurative inflammation of the cellular tissue about the kidney and of its fatty capsule. It may originate from inflammation of the organ extending outward, from the rupture of a renal abscess, or from secondary infection of a blood-clot surrounding the kidney which has been produced by some injury of the organ. In the traumatic cases the infection is usually derived from the

kidney itself. The perinephritis may also be the result of other inflammatory processes in that neighborhood, originating in the bones or from perforating ulcer of the stomach. *Perinephritic abscess* may extend upward, traversing the diaphragm either by perforation or by infection of its lymphatic channels, and causing an empyema or even perforating the lung. It may also perforate the intestines or the stomach, and much more rarely does it burst into the pelvis of the kidney itself. The abscess frequently descends by gravity behind the peritoneum, and it may discharge in the groin or low down on the back. The infection may be the ordinary pyogenic form, or it may be tuberculous, in the latter cases forming the ordinary cold abscess.

Symptoms.—The symptoms of perinephritis are pain in the back and side, and fever with or without an initial chill. Local tenderness is marked, a large tumor develops, the thigh may be held flexed by contraction of the psoas muscle, and the patient may bend the spine towards the injured side. Fever may precede the appearance of a tumor. If it be purely tuberculous in origin it produces no symptoms other than those of an ordinary cold abscess. The diagnosis of perinephritis from pyonephrosis or abscess of the kidney is made by the more superficial situation of the pus, by the greater immobility of the tumor, and in some cases by the absence of urinary signs of kidney disease. The urine will be altered in pyonephrosis, unless that from the affected side is entirely shut off by the obliteration of the ureter. The swelling of the perinephritic abscess is more obvious in the back and less so in the front than the tumors made by distention of the kidney. Neoplasms of the kidney are usually movable, and do not present the signs of inflammation. Aspiration will furnish pus in cases of abscess. It should not be forgotten that perinephritis is often associated with suppuration in the kidney. A perinephritic abscess might easily be confounded with a subphrenic abscess developing from a perforation of the stomach, but it can usually be distinguished by the fact that the pus lies against the posterior wall of the abdomen rather than up under the diaphragm, although in some cases perinephritic suppuration may form a true subphrenic abscess. The absence of stomach symptoms and the presence of disease of the kidney would assist in the diagnosis. Cold abscesses originating in the bones and forming in this locality may be distinguished by the signs of disease of the vertebræ, the pelvic bones, or the ribs, and also by the absence of signs of kidney disease. Psoas abscesses are situated near the middle line, whereas a perinephritic abscess may extend well out into the flank. The diagnosis is by no means always easy, and may be impossible.

Treatment.—The treatment of perinephritis consists in evacuation of the pus by incision as soon as the diagnosis can be made. Unless the symptoms of kidney disease are urgent, that organ should be left untouched until the external abscess-cavity has contracted, except when the perinephritis is secondary to a pyonephrosis with complete destruction of the kidney, in which case the organ should be removed at once. These abscesses should be opened by a large incision similar to that used in nephrotomy, which will allow of examination of the condition of the kidney. In the tubercular cases, after removal of the kidney the external abscess may be treated with iodoform.

Tuberculosis.—Tuberculosis generally infects the kidney by ascending from the bladder along the ureter. In some cases it is primary in the kidney, the infection being carried by the blood-vessels. It is also possible for the kidney to be involved by a local extension of a neighboring tuberculous focus in the bones of the spine or the ribs, or in the peritoneum or intestine, but these cases are exceedingly rare. Tuberculosis of the kidney appears under several forms, probably the most common being the miliary form, corresponding to the similar condition seen in other organs, and associated with so many lesions elsewhere that it has no practical interest for the surgeon. Single primary tubercular foci occasionally develop in the kidney, forming cheesy masses which sometimes attain a large size or degenerate into cold abscesses. In rare cases the changes may remain limited to one part of the kidney, but the disease usually involves the entire organ and spreads to the pelvis, even when it originates in the parenchyma. A common variety of tuberculosis of the kidney, however, is that due to ascending infection from tuberculous disease of the bladder. In these cases the gross lesions resemble those of pyonephrosis in general, except that the amount of granulation-tissue and cheesy masses makes the tumor rather solid than cystic. It is probable that a large number of cases of supposed ordinary pyonephrosis are really due to tubercular infection, as it is often impossible to demonstrate the tuberculous origin of such advanced lesions. A perinephritis may exist with the tuberculosis, being of the cold abscess type and due to infection from the kidney. If the renal disease is primary, it is likely to infect the bladder at an early date by extending along the ureter, or, without involving the latter, by attacking the bladder-wall at once. The renal focus, however, may be the primary lesion and may exist without serious tuberculous disease in any other organ of the body—a fact which is of great importance in estimating the prognosis of these cases and the possibility of a cure by removal of the kidney.

Symptoms.—The symptoms of renal tuberculosis are almost invariably those of bladder disturbance, such as hæmaturia or frequent micturition. The latter may be due merely to increased quantity of urine or to vesical irritation. It is seldom that the diagnosis can be made (by finding bacilli in the urine, for instance) before any lesion has developed in the bladder. The symptoms referable to the kidney itself are the presence of a tumor and a feeling of lumbar uneasiness, together with the general symptoms of anæmia and cachexia characteristic of tuberculous disease. A cystoscopic examination of the bladder should always be made, and it will sometimes allow of a very early diagnosis by the discovery of minute tubercular ulcerations near the mouth of the ureter on the affected side. The prognosis of tuberculosis of the kidney appears to be absolutely hopeless under general treatment when the symptoms are sufficiently advanced to permit a diagnosis to be made. In very early cases radical operations have effected a permanent arrest of the disease, and even when the local lesion is far advanced life may be prolonged by proper surgical treatment.

Treatment.—The treatment of renal tuberculosis depends upon the extent of the disease in general. If it is practically limited to one kidney, the lungs or glands being only slightly involved, nephrectomy may result in a

radical cure. A slight infection of the bladder or of the prostate does not contra-indicate the operation, as it will often improve or disappear afterwards. Nephrectomy may be satisfactory even when a well-marked pyonephrosis is present, if the other organs are not seriously affected. In cases in which there is extensive disease elsewhere, and especially in the other kidney, nephrectomy should not be done, and such cases are best treated on general principles, with due attention to the condition of the bladder. Nephrotomy results in permanent urinary and tuberculous sinuses, and is apt to hasten the end; but when the ureters are occluded by any cause, or when the suppuration is so intense as to threaten septicæmia or pyæmia, the surgeon may be compelled to incise and drain the abscesses or the kidney itself. Iodoform treatment must then be instituted, with due care to avoid poisoning.

Tumors.—The tumors of the kidney are solid or cystic, the cystic forms being the congenital cystic kidney and hydronephrosis. Hydatid cysts are so rare as to need only mention here. Minute cysts develop in the kidney in the course of chronic nephritis, but are of no surgical importance. Single serous cysts are occasionally seen in kidneys otherwise healthy, but rarely attain the size of an egg or an orange.

Congenital Cysts.—Congenital cystic kidneys arise in the same way as cysts of the ovary and congenital cysts of the liver (with which they are sometimes associated), and, although of congenital origin, they grow slowly and are seldom noticed until the patient has reached adult life. These cysts are generally multiple and of all sizes from a pin's head up to a man's fist, the entire organ often being converted into a multilocular cystic mass, and yet, in spite of this change, the unaltered parts of kidney-substance continue to secrete urine until they become atrophied from the pressure of the growing cysts. In the great majority of cases both kidneys are affected. The condition gives few symptoms, and is often accidentally discovered at autopsies, having been unnoticed during life. In other cases the tumors are very large and cause symptoms by their pressure, and we have been compelled to operate on one such tumor which extended from the diaphragm to the crest of the ilium and caused vomiting and various nervous disturbances by its great size. As the condition is bilateral, removal of the kidney is not to be thought of, and drainage should be established by a nephrotomy, one cyst being broken into after another, converting them as far as possible into one cavity which can be drained through the wound. A permanent urinary fistula results, and therefore it is best to leave these kidneys untouched unless compelled to interfere by serious symptoms.

Hydronephrosis.—Hydronephrosis is a dilatation of the kidney by accumulation of urine in its pelvis owing to obstruction of the ureter. The ureter may be deficient congenitally, or obstructed by cicatrices, by a stone, by the pressure of a tumor in the pelvis, or simply by being bent upon itself as may occur in a case of floating or movable kidney. By far the most common cause is movable kidney, and hence the affection is four times as common in women as in men. Its symptoms are frequently first noticed during pregnancy. Moderate dilatation of the kidneys may be produced by any obstruction to the outflow of urine in the bladder or urethra,

and is then bilateral in most cases. The symptoms of this condition when it occurs gradually are so little marked as to be unperceived until the tumor reaches a considerable size, for the other kidney gradually hypertrophies and does the work of both. When a ureter is suddenly blocked by a calculus or by a twist, the patient is seized with intense pain in the renal region, which may be so severe as to be uncontrollable by morphine, and uræmia may develop The kidney can be felt enlarged and tender. In a case of floating kidney repeated attacks of obstruction of the ureter may occur with intervals free from symptoms, and the name of **intermittent hydronephrosis** has been given to this condition. The retention may pass off with a sudden rush of urine to the bladder, which may have to be emptied three or four times at short intervals, the flow bringing relief from pain and the disappearance of the tumor. When the obstruction is chronic the only sign may be the tumor developing in the renal region, which may attain a large size, extending downward to the pelvis and across the middle line. This tumor seldom is tender or occasions pain, but vomiting may be produced by direct pressure on the stomach or by dragging on the attachments of the pylorus. The fluid of the cyst is of low specific gravity, and contains but little urea. The result of chronic hydronephrosis is the destruction of the kidney-substance as it is flattened out in the wall of the cyst until finally scarcely a trace of it may be left. In some cases the tumor has ruptured and caused peritonitis, usually fatal.

Treatment.—The treatment of intermittent hydronephrosis, if it is due to extreme mobility of the kidney, which is usually the case, is fixation of the organ in its proper position, which prevents a return of the obstruction. In the chronic form the kidney-substance may be so altered as to be useless, and nephrectomy is the best treatment. The cyst may be drained either extraperitoneally or through the peritoneal cavity by suture of the sac-wall to the parietal peritoneum, and, as a rule, the drainage will cease spontaneously, owing to the complete destruction of the kidney-tissue. If discharge of the urine through the fistula should persist, nephrectomy may be performed by cutting down on the remains of the kidney and the cyst and removing the entire mass. If operation is impossible because of the patient's condition, the cyst may be emptied by aspiration, and cases are on record which have been cured by repeated aspiration; but this method is not without danger, for infection may take place and suppuration result.

Solid Tumors.—The solid tumors of the kidney are almost invariably malignant, although adenomata or lipomata are occasionally found, as well as mixed tumors of congenital origin containing lymphoid tissue and often some striped muscular fibres, and resembling the mixed tumors of the parotid. The mixed tumors are supposed to originate from misplaced fragments of the suprarenal bodies lodged in the kidney-substance.

Lipoma of the fatty capsule of the kidney is quite common, and forms large retroperitoneal tumors, the diagnosis of which from lipoma of the mesentery is not easy. The situation of the tumor, however, and its resemblance to the kidney in shape, will aid in making the diagnosis. These tumors are innocent, and may be left untouched unless they attain a large size and cause symptoms by pressure upon various organs. **Adenoma** of

the kidney rarely exactly reproduces the kidney-structure, and is not altogether benign, rather resembling adenoma of the rectum in its tendency to form secondary tumors and to return after removal. These tumors are usually small, and have been successfully removed by partial resection of the organ.

The most common tumor of the kidney is **sarcoma**, which usually develops in children in the first two or three years of life and forms tumors of immense size, more than half filling the abdomen. These tumors occasion no symptoms, as a rule, until they have reached their full growth, when digestion and respiration are embarrassed by their pressure and the child falls into cachexia. The tumors may be hard or soft, and are occasionally cystic. They retain more or less the shape of the kidney, and seldom cause urinary symptoms. Both kidneys are rarely involved. Late in the disease there may be hæmaturia and metastasis to other organs. Removal is the only possible treatment for these tumors, and if it is undertaken early a permanent cure may be hoped for; but in the great majority of cases the disease is recognized too late to admit of a cure, and if extirpation is possible at all it is usually incomplete, and recurrence follows.

Carcinoma of the kidney is a disease of later life, especially after the fiftieth year, when sarcoma of that organ is almost unknown. The tumors are not so large as in sarcoma, but may attain a considerable size, even that of a man's head. The neoplasm almost invariably causes profuse hæmaturia, which may be intermittent. Pain is an uncertain and late symptom, and cachexia appears in the later stages. Vesical symptoms are induced by the blood in the urine, and if infection takes place an acute pyelitis or cystitis develops, with severe symptoms. Death is usually the result of the exhausting hemorrhages or the infection. Nephrectomy for malignant disease in the adult, while giving better operative results than in children, has seldom effected a permanent cure.

The Diagnosis of Tumors of the Kidney.—The kidney is accessible to palpation, when the patient lies upon his back and the surgeon faces him at the side, placing one hand in the lumbar region to lift the kidney up towards the anterior abdominal wall, while the other hand makes firm pressure in front and maps out the organ. In thin individuals with lax abdominal walls quite small tumors of the kidney may be recognized, while in others it is impossible to reach the normal organ without an anæsthetic. As a rule, the lower half of the right kidney can be palpated readily, but the left kidney not so easily. Tumors of the kidney are usually rather fixed in the lumbar region unless the kidney from which the tumor has developed is itself movable. They do not move with respiration unless they attain such a size as to press upon the under surface of the liver or of the diaphragm and thus have movements imparted to them. When firmly held they do not follow the ascent of the diaphragm. As the kidney lies behind the peritoneum at the attachment of the ascending and descending colon, a tumor growing in the kidney carries this part of the intestine forward with it, and the bowel can usually be recognized as a sausage-like mass or as a line of tympanitic resonance on percussion crossing the front of the tumor. The area of percussion dulness of the tumor and its relations to the liver and

spleen should always be made out. Except in the case of floating kidneys, the usual dulness in the lumbar region will be present.

Congenital cystic kidneys may be recognized by the fact that both kidneys are diseased, by the uneven surface of the tumor, some of the cysts standing out above the general level, and by the complete absence of symptoms. Hydronephrosis of the intermittent variety is recognized by the typical symptoms. Chronic hydronephrosis can be distinguished from ovarian cyst by the fact that the tumor has appeared above instead of below, and by the area of dulness on percussion extending to the flank, while aspiration will furnish the peculiar fluid of these cysts. The cyst will lie upon one side rather than in the middle line, and may therefore be distinguished from some pancreatic cysts, and there will be none of the signs of pancreatic disturbances of digestion. On the right side of the body they may resemble cysts of the gall-bladder, and the resemblance may be increased by the similarity of symptoms caused by the passage of renal and biliary calculi. But the extension of the tumor into the back, the dulness on percussion over an area on the anterior surface of the cyst and continuing into the lumbar region, together with the presence of the colon on the front of the tumor, and the evident independence of the tumor from the liver, should enable the diagnosis to be made. The solid tumors of the kidney preserve more or less the shape of the organ, and the thick rounded border and hilum can often be recognized. The shape distinguishes these tumors from tumors of the spleen, which have the sharp edge of that organ and an angular notch upon the inner border. Renal tumors seldom are tender or give rise to pain, except in the malignant varieties. They may occasion vomiting by pressure upon the stomach, or by dragging upon the attachments of the pylorus and the duodenum. Hæmaturia is characteristic of carcinoma, and fragments of the neoplasm may be passed with the urine. The condition of the two kidneys should always be studied separately by catheterization of the ureters by means of the cystoscope, or by Kelly's method. As many of these cases require nephrectomy, it is all-important that the health of the remaining organ should be perfect.

Renal Calculus.—Stone in the kidney is often of congenital origin, uric acid infarcts of the renal tubules being almost the rule in newly born infants, and if any of these crystals remain in place, not being washed out by the first flow of urine, they form a nucleus for further deposit upon which a stone may grow, although it may cause no symptoms until later in life. Renal calculi are usually of branching shape, the main trunk lying in the pelvis, with short branches extending into the various calyces. Renal calculi are composed of phosphates, calcium oxalate, or uric acid. Stones are usually confined to one kidney, but they may be single or multiple. They are more common in males than in females.

Symptoms.—A calculus may remain in the kidney and attain a large size, with very few or absolutely no symptoms, but in the majority of cases there is pain upon that side and blood appears in the urine. The symptoms are increased by motion, such as rough jolting in a wagon, but attacks of pain also come on at night while the patient is resting in bed. If infection takes place through the bladder and ureter, the symptoms of pyelitis are

added to those already present. Pus is then found in the urine, there may be some fever, and the pain and tenderness are increased.

The stone sometimes becomes lodged in the entrance to the ureter and closes it temporarily, giving rise to severe **renal colic**, which may last until the stone works its way back again into the pelvis of the kidney. Small stones may also occasion renal colic as they pass down the ureter into the bladder by obstructing the flow of urine. The symptoms may last only a few hours, or may recur at short intervals for weeks and months as the stone slowly descends. Renal colic is very apt to come on after severe exertion, the stone being thus dislodged from the kidney and entering the ureter, but it may also occur while the patient is asleep. If the calculus is large enough to block the ureter, it gives rise to excruciating pain, with a feeling of fulness and tenderness in the loin, and neuralgic pains shooting down into the testicle with retraction of the cremaster, or extending down the thighs. The pain may also resemble intestinal colic and be associated with rectal tenesmus. The urine is acid, often contains blood, and a trace of albumin and pus may be present when infection has occurred. There may be a rise of temperature, the heart-action becomes weak, and the patient may faint or vomit. The urine may be clear during the attack when that from the diseased side is entirely excluded, or it may be bloody if the obstruction is incomplete. Micturition is apt to be frequent, with some tenesmus. There are a number of these spasmodic attacks, until the stone slips back into the pelvis of the kidney or makes its way down into the bladder, when it may be passed through the urethra or may form a nucleus for a vesical calculus. Very small stones sometimes give rise to severe attacks of renal colic, as they excite spasmodic muscular contraction of the ureter in their passage down the canal. Rarely the stone remains impacted in the ureter, ulcerates its walls, and forms a urinary abscess around it. Cystitis is very often observed as a secondary consequence of renal calculi when some external infection has taken place.

Diagnosis.—The diagnosis of renal colic is made by the renal and vesical symptoms, the retraction of the testicle, and the peculiar direction of the pain, gall-stone colic causing pain in the right shoulder and hepatic tenderness, and intestinal colic causing pain in various parts of the abdomen. The diagnosis of renal calculus depends upon the urinary symptoms, the hæmaturia being less than that of carcinoma of the kidney and more than that of pyelitis, and upon the local pain and tenderness and the intermittent character of the symptoms. Cases with indistinct symptoms often escape recognition. Malarial attacks and neuralgia of the kidney sometimes simulate its symptoms. Renal hemorrhage from any cause is apt to be accompanied by renal colic from blocking of the ureter by clots, and a twist of the ureter by displacement of a movable kidney will also cause attacks of colic. In any case in which there is very severe renal pain of doubtful origin, an exploratory nephrotomy should be undertaken, because, even if no stone be found, the operation generally improves and may even cure the patient. The prognosis of a renal calculus which is too large to pass down the ureter is bad, on account of the loss of blood, the severe attacks of pain, and the tendency to inflammation upon the least infection of the urinary

organs. Smaller stones are also dangerous, because they are apt to form the nuclei for vesical calculus.

Treatment.—The treatment of renal colic consists in opiates, warm applications to the abdomen and loins, a hot bath, warm drinks in abundance, and stimulants in moderation. Opium should not be given too freely, for toxic symptoms have been known to follow large doses when the patient was suddenly relieved of pain by the passing of the calculus. If a calculus is passed into the bladder and does not soon appear in the urine, the bladder should be washed out with the evacuator, as after a litholapaxy, in order to avoid the danger of the subsequent development of a vesical calculus. When there is proof of the presence of a calculus in the kidney, the stone should be removed by exposing and incising the kidney, as in the operation of nephrotomy. When the kidney is exposed, the stone can usually be felt by palpation of the organ between the fingers, and resembles the terminal phalanx when felt through the pulp of the finger. If there should be any doubt as to the presence of a stone, the kidney may be exposed by the operation of nephrotomy and explored with a long needle. The use of the needle, however, is not always conclusive, and if the sufferings of the patient are great enough to warrant exposing the kidney, it is wiser to incise the organ and insert a finger into the pelvis for thorough palpation. If suppuration is present, the kidney must be drained, otherwise the opening in it should be sutured after removal of the stone and the external wound closed also, a gauze drain being left in one angle of the wound.

Operations upon the Kidney.—Nephrorrhaphy.—Of the many operations devised for this purpose we will describe only two. The patient should lie on the side opposite to the affected kidney, with a large firm pillow in the hollow between the ribs and the pelvis, the body being inclined slightly forward.

In the first operation an oblique incision is made parallel with the twelfth rib and two finger-breadths below it. The muscles are divided in the same line down to the transversalis fascia, which is also divided. The fatty capsule of the kidney is then opened, while an assistant grasps the kidney through the anterior abdominal walls and forces it up into the wound. The true capsule being exposed, it is incised on the convex border for the entire length of the organ and peeled back on each side, making two flaps, which are secured by sutures to the transversalis fascia on each side of the wound. The external wound may then be packed down to the bottom, in order to obtain healing by granulation and thus connect the kidney directly with the external surface by a firm mass of cicatricial tissue.

In the second method (Edebohls's) the operation is the same down to the formation of the flaps in the capsule. Three or four deep sutures of silkworm-gut or chromicized catgut are then passed directly through the substance of the kidney along the line of the incision in the capsule and also through the muscles on the sides of the wound. These are left untied, and the kidney is merely held in the bottom of the wound by them for the present. The flaps of the external capsule of the kidney are left turned back, so as to leave the kidney exposed, but are not sutured to the muscle. Buried

sutures are then passed through the muscular part of the wound on each side, drawing the cut edges together in its entire extent. The deep sutures in the kidney are then drawn fairly tight and tied, in order to keep the organ against the muscles, and the skin and fascia are next sutured. The patient should be confined to bed for three weeks, in order to obtain firm cicatricial tissue in the wound before any strain is put upon it. It is absolutely necessary to open the fibrous capsule of the kidney in doing this operation, as strong adhesions cannot otherwise be obtained. The sutures do not seem to affect the renal tissues, and cause no symptoms after the operation, except that a few drops of blood may be found in the urine. It is seldom possible to replace the kidney exactly in its normal position, but this appears to be of little importance provided that it be firmly fixed. Some operators, therefore, have united it to the abdominal wall very much lower down, and this would be allowable if adhesions existed which prevented the return of the organ to its natural situation. The results of nephrorrhaphy appear to be good and permanent.

Nephrotomy.—Nephrotomy is the operation of incising the kidney. The kidney can be reached by an oblique incision beginning at the edge of the quadratus lumborum at its attachment to the twelfth rib and passing obliquely forward and downward, terminating about an inch above the crest of the ilium. The patient should be in the position already described. The skin, subcutaneous fascia, and muscle are divided in order, and the peritoneum exposed in the anterior angle of the incision. The kidney is then sought in the posterior angle and seized by its fatty capsule and brought into the wound. An opening is made in the fatty capsule, which readily strips off the kidney, and the organ is steadied by the pressure of an assistant's hands on the abdomen and by the operator's fingers in the wound. Incisions can then be made into any part of the kidney, but, as a rule, it is best to make them through the kidney-substance rather than directly into the pelvis, as the latter incisions are apt to leave a permanent urinary fistula. The hemorrhage from the kidney is brisk and yet not extreme, and the incision may be made with an ordinary scalpel, but it should be only large enough to admit the finger, and the latter should be promptly thrust into it. While the surgeon is making the exploration the pressure of the finger will control the hemorrhage, and the insertion of the sutures will finally arrest it. The incision in the kidney-substance may be sutured and primary union obtained. Three or four deep sutures of catgut are employed, and the external wound may then be closed, a drainage-tube or a wick of gauze being carried down to the surface of the kidney near the sutured point, in order to make sure of drainage in case the sutures do not hold. After a nephrotomy there is frequently blood in the urine for a few days, and it may be so abundant as to form clots in the ureter and in the bladder, with colic and other symptoms of blocking of the ureter or of the urethra. When nephrotomy is performed for drainage also it is better to make the incision through the substance of the kidney rather than through the pelvis, and the drainage-tube may be inserted through this opening into the pelvis. The tissue of the pelvis itself is too thin for the successful application of sutures, and leakage usually follows.

Nephrectomy.—The kidney may be removed by an anterior incision, by traversing the peritoneal cavity, or by an extraperitoneal operation. A small kidney may be removed by the incision just described for nephrotomy, and for larger tumors the same incision may be prolonged towards the middle line without opening the peritoneal cavity, if the peritoneum be stripped off the anterior abdominal wall as the incision is extended. An extraperitoneal operation may be made through an incision parallel to the external border of the rectus, but somewhat farther out, through which the peritoneum is reached, and the latter stripped off the anterior and lateral walls of the abdomen until the kidney is exposed. If necessary, the wound may be enlarged by dividing its external lip at its centre, at right angles to the first incision, which produces a ⊢-shaped incision and gives abundance of room and yet does not directly invade the peritoneal cavity. In cases of pyonephrosis it is necessary to operate extraperitoneally, on account of the danger of infecting the peritoneal cavity. Even in cases of solid tumors without infection it is wise to employ this operation, because the ureter must be left in the pedicle and is a frequent source of infection. For a tumor of very large size, however, the transperitoneal method has frequently been used with success, the mortality being but little higher than that of the extraperitoneal operation. In the transperitoneal method the incision may be made in the middle line or at the external border of the rectus, opening the peritoneal cavity directly. The abdominal contents are pressed over to the opposite side of the middle line and thoroughly protected by sponges or pads of gauze. The peritoneal coating of the kidney is then opened on the outer side of the colon and the latter displaced inward, when the kidney can be dissected from its bed and lifted into the wound. The ureter and vessels are separated bluntly and tied with separate ligatures. If the ureter is full of infectious material, it should be secured in the anterior abdominal wound. If not, it may be dropped back with the rest of the pedicle and the posterior layer of peritoneum united over it.

In the extraperitoneal method the kidney is freed from its attachments and brought outside of the wound if possible. A double ligature is then passed through the pedicle and tied without attempting to separate the vessels and the ureter, as it is rarely possible to obtain a good view of these parts, and the renal vein has very thin walls. The kidney is cut away from the pedicle and removed. If desired, the ureter can then be dissected from the vessels and tied separately, but, as a rule, it is unnecessary, and the wounds heal well with slight drainage. If any rent has been made in the peritoneum, it is either closed at once or protected with gauze or sponges and closed at the end of the operation. The external wound is closed with deep or buried sutures, a small opening being left for drainage by a tube or wick of gauze. The drainage-sinus is sometimes troublesome in healing, often refusing to close until the ligature has separated and been removed. One advantage claimed for the intraperitoneal operation is that it enables the surgeon to determine the condition of the other kidney by direct examination, but if this is important a separate incision can be made for this purpose and closed before doing an extraperitoneal nephrectomy.

INJURIES AND DISEASES OF THE URETERS.

The ureters are liable to many congenital **abnormalities,** the most frequent being their reduplication on each side, the pelvis of the kidney being also double in some cases. These variations, however, are of little importance surgically, except when congenital occlusion results in the conversion of the kidney into a cyst, producing hydronephrosis. The ureters are often dilated when there is obstruction of the urinary passages at some lower point. The diseases of the ureter are generally masked by the symptoms of kidney or bladder disease which are antecedent or secondary to them. The most important lesions of the ureter are injuries in the course of operations, strictures, impacted calculi, and tuberculosis. Catheterization of the ureters is possible by cystoscopy, as described in the section on the Bladder.

Wounds.—The ureter is not infrequently wounded in operations upon the uterus and other pelvic organs, being either directly incised or torn or included in a ligature, and a fistula forms, through which the upper end of the ureter discharges urine. When the ureter has been wounded in an operation, the proximal or renal end of it may be secured in the abdominal wound, so as to prevent the discharge of the urine into the abdominal cavity. To this operation might be given the name *ureterostomy.* Wounds of the ureter have been treated successfully by suture even in cases of circular division, a catheter being placed in the canal and pushed down into the bladder and the divided ends united over it, or a lateral implantation of the upper into the lower end being made.

Ureteral fistula has often been treated by the removal of the kidney, the healthy kidney being sacrificed in order to rid the patient of the annoyance of the urinary discharge, but recently successful attempts have been made to save the kidney by grafting the ureter into the bladder or even by closing the fistulous opening by uniting the divided ends of the ureter. Grafting into the rectum is feasible, but is likely to result in pyelitis from ascending infection, and is not to be recommended.

Stricture of the ureter may be the result of inflammatory processes, but is most frequently due to a bend in the duct caused by a displaced kidney. These cases seldom come under the care of the surgeon until a hydronephrosis has been produced and the kidney is too far destroyed to admit of saving it by treatment. Strictures have been successfully dilated by instruments introduced from the bladder by cystoscopy, or even from above after nephrotomy. They have also been divided longitudinally and the wound united transversely, on the same principle as the operation of pyloroplasty. Strictures low down have been treated by resection and implantation of the ureter into the bladder, and those high up have been excised and the lower end of the duct implanted into the pelvis of the kidney.

A **calculus** sometimes becomes impacted in the ureter, having descended from the kidney, causing complete or partial obstruction of the canal. In such cases the ureter may be exposed and the calculus removed, the external incision to be employed depending upon the situation of the stone. The upper portion of the canal can be reached by opening the

abdomen at the external border of the rectus. The ureter can be incised, the calculus removed, and the wound in the canal closed with sutures. The posterior layer of the peritoneum should be united over the ureter, and if there is danger of leakage a drain should be introduced through a small wound in the lumbar region, so that the anterior abdominal wound can be closed. To expose the ureter lower down an oblique incision is made parallel to Poupart's ligament, but an inch above it, the peritoneum being separated from the pelvic wall as in the operation for ligature of the iliac artery, until the pelvic portion of the ureter is reached. The upper part of the ureter is adherent to the peritoneum, and follows that membrane when it is stripped up. The extreme lower end may be reached by the vagina in the female or by resection of the sacrum, as in Kraske's operation for exposing the rectum.

THE MALE GENITALS.

THE PENIS.

Congenital Malformations.—The penis may be **absent** in very rare cases, and is occasionally found in a rudimentary condition buried under the integument of the pubes or of the scrotum. In extreme cases of this deformity castration may be advisable in order to free the individual from tormenting sexual desire and its resulting nervous disturbances. Milder forms of undeveloped penis sometimes correct themselves at puberty or even later in life, and only require some care as to sexual hygiene. Cases of **double penis** have been reported, but usually with a supernumerary limb between the two sets of genitals. The double penis may be merely a cleft penis, or may be double in the whole or in part of its length, the two parts being sometimes included in a common sheath of skin, sometimes separate. The deformity is very rare. The penis may also be **twisted** upon itself, so that the urethra winds about the organ and opens upon its upper side. Among the commonest deformities of the penis is an unnatural narrowing of the meatus or of the opening in the foreskin. An imperforate meatus is occasionally seen, the opening being closed by a very thin membrane. The narrow and the imperforate meatus have been described in the chapter on the Urethra. Besides the urinary obstruction, a narrow meatus may occasion sexual hyperæsthesia.

Phimosis.—Phimosis is a term applied to a redundant foreskin with a contracted orifice. (Figs. 852 and 853.) The foreskin may be redundant and yet its orifice be sufficiently large, a condition which is not a true phimosis. At birth the opening in the foreskin is minute and the inner layer of the membrane is usually adherent to the outer surface of the glans. During childhood the orifice enlarges and the adhesions slowly separate, and at puberty the former should be large enough to give free exit to the glans. In some cases the opening in the foreskin remains very small, so that even the urine escapes with difficulty, and instances have been known in which individuals have reached adult life in this condition, the foreskin ballooning out at each act of urination, and being evacuated by pressure with the hands. The retention of urine causes great inflammation of the parts, and calculi

may form between the foreskin and the glans. A narrow preputial orifice is followed by the same consequences as a narrow meatus—distention of the urinary channels and various nervous conditions. The milder forms interfere with the cleanliness of the glans because the foreskin cannot be retracted, and the

Fig. 852.

Phimosis—the orifice.

Fig. 853.

Phimosis—the redundancy.

sticky secretion known as *smegma* collects and gives rise to balanitis or intensifies any venereal inflammation. A foreskin with an orifice of good size but adherent to the glans may also cause frequent micturition or sexual hyperæsthesia, and may give rise to the habit of masturbation on account of the local irritation.

Treatment.—A narrow preputial orifice should be enlarged by the operation of circumcision, which consists in removing a portion of the foreskin, or by a simple dorsal incision. The latter expedient is useful in cases of extensive venereal disease, in which it is desirable to make the wound as small as possible, for fear of infection of the fresh wound surfaces, but even in such cases it should be followed later by a typical circumcision. In the adherent prepuce of children, if the orifice is fairly large and the foreskin not redundant, it is allowable to separate the adhesions without any cutting operation. The mother must then be taught to draw the foreskin back daily and to cleanse the glans carefully, replacing the foreskin to avoid paraphimosis.

Circumcision.—The operation of circumcision is begun by seizing the edges of the preputial orifice with two or three artery clamps and thus putting the inner layer of the foreskin upon the stretch. A special preputial clamp, or the handles of a pair of scissors which come together flatly, are then placed upon the prepuce so as to grasp it from side to side, the clamp being at an angle of about forty-five degrees with the long axis of the organ and parallel with the dorsum of the glans. The redundant part of the foreskin is then cut away with a sharp knife or with a pair of scissors, keeping close to the clamp on the side next to the glans. Unless

the knife is very sharp, it is best to transfix the flap of skin in the centre and cut outward in order to make a smooth cut. The cutaneous layer of the prepuce then retracts, leaving the raw surface of the inner layer exposed. The opening in the inner layer must then be enlarged by a dorsal median incision extending to the corona, and the two triangular flaps thus made are peeled off the surface of the glans by tearing the adhesions or dissecting them away with a knife if they are very strong. In infants, as a rule, the inner layer of the prepuce can be split by seizing it with the thumb-nails so as to tear it and separate the adhesions at the same time. The accumulated smegma must be thoroughly removed, the sharp corners of the inner flaps cut away and rounded, and then the inner layer united to the outer by interrupted sutures. (Fig. 854.) There is usually no hemorrhage of moment, and if the artery at the frenum should be troublesome it may be included in one of the sutures. Special care must be taken in making the incision not to slice off the end of the glans, an accident which may readily occur if strong adhesions exist, and not to shorten the frenum too much, because of the disagreeable dragging a short frenum causes during erection. The oblique incision avoids the latter error, and also makes the opening larger. Thorough asepsis should be observed, and at the conclusion of the operation the wound is dressed by winding a strip of gauze around the penis. This may be secured in place by collodion or by strips of rubber plaster. In infants the dressings will be constantly wet with urine, and should be removed after the first twenty-four hours, the mother applying sterilized gauze covered with boric acid ointment after each urination. In nervous individuals and in children it is wise to employ general anæsthesia for circumcision, but in the ordinary adult the operation can be performed under cocaine, and in infants no anæsthesia is necessary, as the operation may be completed in a few minutes, and the pain is not lasting.

Fig. 854.

Result of circumcision—sutures in place.

Paraphimosis.—If a prepuce with a moderately tight orifice be drawn backward over the glans in play, in violent coitus, or in attempts to uncover the glans for washing, especially during the existence of venereal disease, the narrow band may be caught behind the corona, and the individual will be unable to draw it forward again. To this condition the name of paraphimosis has been given. The constriction of the narrow band around the organ impedes the circulation of the glans, and the inner layer of the prepuce, which is usually everted as the prepuce is retracted, then becomes œdematous, and may slough if the pressure is not relieved in time. As a rule, the constricting bands slough first, and the circulation is thus restored sufficiently to prevent complete gangrene of the parts beyond. As the result of the swelling the inner layer of the prepuce forms a series of transverse folds with deep fissures between them, but the greatest constriction will always be made by the edge of the preputial orifice, and is usually found at the uppermost of the transverse fissures.

Treatment.—To reduce a paraphimosis the parts should be immersed in very hot water for some time; then the surgeon takes the organ, well lubricated, between his hands, placing the forefingers and middle fingers around it behind the constriction and compressing the glans and swollen layer of the prepuce with the thumbs, while at the same time he endeavors to force the glans back and draw the sheath forward with the interlocked fingers. Or the organ may be seized in one hand and the swollen parts compressed between the fingers and the thumb of the other, forcing them at the same time backward. (Fig. 855.) All attempts at reduction should be preceded by concentric pressure or the application of an elastic bandage, in order to reduce the œdema as far as possible. Multiple scarification may be employed with the same end in view. The reduction may be so painful that general anæsthesia will be necessary. If the operator can pass his thumb-nail under the constricting band he can usually succeed in reducing the displacement by lifting the band and sliding it forward over the nail. The loop of a hair-pin or a bent wire will also be found a very useful instrument, as it can be inserted under a very tight band, and then by sweeping it around the glans the foreskin may be drawn forward over it in a similar fashion. If the paraphimosis proves irreducible, an incision should be made in the median line of the dorsum over the deepest of the transverse fissures, and carried down until the constricting band is divided. This can easily be done under cocaine anæsthesia, but it is wise to make a long incision and not attempt to divide the band with the point of the knife, for infection is less likely to occur if the parts are thoroughly exposed. In many cases where the extent of the strangulation is not sufficient to cause sloughing the parts become habituated to the impeded circulation, the œdematous folds become filled with newly formed connective tissue, and a permanent enlargement of the end of the organ is produced, which resembles elephantiasis. The treatment of this condition consists in multiple scarification, hot baths, massage, and the elastic bandage. If these measures fail, the hypertrophied tissue may be cut away.

Fig. 855.

Reduction of paraphimosis. (Agnew.)

Injuries.—The penis is rarely injured by accidents, although contusions, and lacerated, incised, and gunshot wounds, occasionally occur. These injuries are accompanied by serious hemorrhage if open, or by the formation of a large hæmatoma if the external wound is small or absent. Sloughing seldom occurs, and even if the entire skin of the penis and the scrotum be torn away, as occasionally results from the bite of a horse or when the organs are caught with the clothing in machinery, the skin is restored with astonishing rapidity. (Fig. 856.) These injuries are often complicated with injuries to the urethra and extravasation of urine, and this is their principal danger. If a plastic operation is necessary to provide a covering for the penis, it may

be done by forming a bridge-like flap from the skin of the lower part of the abdomen, between two horizontal incisions, one at the pubes and the other several inches higher, and slipping the denuded organ under this bridge. One week later one end of the flap is divided and the end turned in and secured around the penis. After another week the other pedicle may also be divided and secured in like manner. The only difficulty in the operation consists in the liability of the wound to infection from the urine.

Fig. 856.

Spontaneous restoration of scrotum after complete loss by sloughing.

Ablation.—The penis has often been amputated by insane persons or in savage warfare without any attempt to control hemorrhage, and recovery has ensued in spite of the great loss of blood.

The forcible bending of the penis while in erection, by a severe blow, by awkward attempts at coitus, or in trying to straighten the curve produced in chordee with the hands, results in an injury to which has been given the name of **fracture** of the penis. The fibrous coat of the corpus cavernosum is ruptured by these means, and a hæmatoma is formed. Recovery takes place with permanent destruction of some of the erectile tissue in the neighborhood of the injury, and results in a curve in the organ during erection on account of the difference between the two sides. This deformity may remain permanently. A severe blow upon the penis when in a flaccid condition may cause it to be displaced under the skin of the pubes, its loose connections with the sheath being broken, and even the firmer union of the glans and the foreskin giving way. This accident, which is called **dislocation** of the penis, most frequently happens in children. Micturition becomes difficult, coition is impossible, and very often the power of erection is also lost. If seen early, these dislocations may be reduced and the penis restored to its natural position, but if neglected it may be very difficult to obtain proper coverings for the organ, even when it has been freed by open incision, as the original cutaneous sheath has become atrophied.

Laceration of the frenum frequently takes place during coitus, and dangerous hemorrhage has been known to follow, but the accident is usually of importance only because it produces a raw surface, which is very liable to venereal infection.

Constriction.—A very common injury of the penis is that produced by placing upon it some tight constricting object, such as a ring, or by tying a string around it in its flaccid state, which cannot be removed when erection follows. The erection is succeeded by permanent swelling of the parts beyond by œdema, and, as shame is apt to prevent the immediate disclosure of the fact, the removal of the object may become exceedingly

difficult. Extraordinary cases are on record in which a cord tied tightly about the organ has been left in place for years, and has even cut its way across the urethra and become entirely buried in the tissues of the organ, which have healed over it. *Treatment.*—The œdema should be treated by an elastic bandage, or by multiple punctures or scarification under aseptic precautions. A ring can sometimes be removed by winding a narrow bandage tightly over the distal part, then passing the end of the bandage under the ring and pulling upon it, thus forcing the ring off as the bandage unwinds. If this fails, a long incision should be made, giving free access, so that the surgeon may see distinctly what he is doing, and the string or ring divided with scissors, cutting pliers, or file. It may be necessary to call in a mechanic to complete the work where heavy metal objects have been employed.

Inflammations.—**Cellulitis** and **erysipelas** are observed in the penis, but usually as the result of urinary extravasation or venereal infection, and they do not differ from those inflammations in general, except that very early incision is necessary in order to prevent sloughing of the sheath.

Balano-posthitis.—*Posthitis* is an inflammation of the prepuce usually confined to its internal lining, and *balanitis* is a superficial inflammation of the glans. As a rule, these two structures are attacked at the same time by inflammation, and the common cause is the retention of urine, smegma, or pus by the foreskin. The inflammation may be merely hyperæmia with increased secretion, or it may be suppurative or ulcerative. **Lupus** and **diphtheritic inflammations** have also been described. **Ulceration** of the glans and prepuce is most frequently of venereal origin, but it may be due merely to the intense infection caused by the retained secretion. **Herpetic vesicles,** similar to those so frequently seen about the mouth, also attack the glans, and are exceedingly difficult to cure, as relapse is the rule. They are small vesicles, about the size of a pin's head, filled with clear serum, which becomes cloudy later, and on bursting they leave a superficial ulcer with a white base and a pink inflammatory areola.

Treatment.—If the foreskin can be retracted, balano-posthitis can easily be cured in most cases by due attention to cleanliness, by carefully drawing back the foreskin, cleansing the parts without rubbing, and laying small pieces of dry gauze between the glans and the prepuce, drawing the latter down over it to hold the gauze in place. The patient should wear a pair of swimming-tights so that the organ shall be held upward against the abdomen. Bandages are difficult to retain upon the penis, and bags for holding the dressings in place are apt to become foul, as they are not changed frequently enough. A fine dry powder, such as bismuth, calomel, or aristol, may be sprinkled over the parts in addition to the dry gauze. In some cases dry dressings are not successful, and recourse must be had to wet dressings, such as weak solutions of chloride of zinc or aluminum acetate, or a mixture of balsam of Peru and castor oil. In other cases the ointments answer best—those of boric acid, zinc oxide, and ichthyol, all about ten per cent. When the foreskin cannot be retracted, the cavity beneath it must be kept clean by irrigation with a syringe with a long

flat beak. Considerable force must be used in the injection in order thoroughly to wash out all the crevices, and a large quantity of water should be employed. Plain warm water answers the purpose, but a solution of 1 to 50 carbolic acid, or of sulphate of zinc three grains to the ounce, may be tried. In all cases that do not respond at once to this treatment the patients should be urged to submit to circumcision, and even when a case does well it is wise to perform a circumcision afterwards in order to prevent a relapse.

Syphilitic and **tuberculous lesions** develop in the penis and on its outer coverings, as has been described elsewhere. A rare form of **tuberculosis** is one which causes necrotic cavities in the centre of the cavernous tissue of the glans, the mucous membrane giving way over it and forming a deep ragged ulcer somewhat resembling a gumma. The **cavernous tissue** is liable to an interstitial inflammation, forming hard fibrous nodules which interfere with erection by shutting off the blood-supply or preventing uniform distention, which produces curvature of the organ. These fibrous indurations are most common in men of gouty habit, and occur late in life. There is no really satisfactory method of treatment. **Lymphangitis** and **phlebitis** are seen in the penis, usually as the result of venereal infection. Lymphangitis may take a chronic form that results in an œdematous thickening resembling **elephantiasis**, but true elephantiasis of the penis is rare in America.

Varicose veins are seen in the penis, and in some cases they apparently interfere with erection by removing the blood too freely. We have succeeded in restoring the power of erection in such cases by ligature of the large dorsal vein. The real value of this procedure, however, is uncertain, on account of the rather hysterical nature of the individuals affected, and may be due to its psychical effect.

Priapism.—Priapism is a condition of prolonged erection of the penis without sexual desire. It is usually a symptom of vesical or pelvic irritation, or of some obscure brain or spinal cord lesion, and in some cases it appears to be due to exhaustion of the lumbar centres of the spinal cord from sexual excess. It is also seen in leukæmia. In many cases, however, its cause is not evident, and it therefore requires description among the diseases of the penis. The erection is usually painful and always uncomfortable, and may last from twenty days to as many weeks. Antispasmodics are of little avail, and the application of ice locally and the protection of the organ from contact with the clothing and bedclothes is all that can be done in the way of treatment. In some cases an incision into the corpora cavernosa has been of benefit. This operation has sometimes been followed by loss of erectile power, but the same result has also been seen in cases not subjected to it.

Tumors.—With the exception of papillomata, the benign tumors of the penis are rare. **Fibroma** and **lipoma** occur, as well as **sebaceous cysts**, the last-named originating from the sebaceous glands of the skin, and also from those behind the corona. These tumors sometimes attain the size of a hen's egg and are a serious inconvenience in coition. **Angioma** is quite common, and usually originates from the blood-vessels, although **lymphan-**

gioma is also met with. Angioma is not so common as upon the female genitals, however, and is most frequently found in infants. When of large size it has been known to interfere with erection by the copious venous anastomosis, which conducts the blood away too rapidly. **Sarcoma** of the penis is rare, but may be found at any period of life.

Papillomata or **warts** are most frequent on the inner layer of the prepuce and on the frenum, but they may be found upon any part of the organ. When they lie under the prepuce they are soft and moist, but when exposed to the air they become dry and hard (Fig. 857), and in some cases the epithelium collects upon them in thick layers so as to form a true cutaneous horn, which occasionally attains a very large size. Papillomata are generally due to the irritation excited by retained secretions caused by venereal infection or mere lack of cleanliness. When caused by venereal disease they are sometimes very numerous, covering the head of the penis or the vulva completely, and attaining a large size. (Fig. 858.) Papillomata appear to have contagious qualities even when there is no evident venereal disease in certain rare cases, and have been known to be transmitted from husband to wife.

Fig. 857.

Horny warts of the prepuce.

Fig. 858.

Warts of the vulva. (Deaver.)

They are also not unlikely to be the origin of malignant disease later in life, and for these reasons they demand prompt and thorough treatment.

Treatment.—In some cases proper attention to the cleansing of the parts and keeping them dry with a dusting powder of calomel, bismuth, and oxide of zinc, will produce a cure without further treatment. Warts should not be ligated, on account of the danger of infection from the sloughing tumor beyond the ligature. When they are small and soft they can be readily destroyed by any of the milder caustics, such as powdered alum or acetic acid, and if they resist these agents, fuming nitric acid should be freely applied until the base has been well burned. The operation may be rendered painless by the application of cocaine. When they have existed for some time the warts may become very hard, and their removal by excision is then indicated, the hemorrhage being readily controlled by pressure and the pain being slight.

Epithelioma.—Cancer of the penis is almost invariably epithelioma, although other varieties are seen in rare instances. It occurs in all parts of the organ, but is most frequent on the glans and inner side of the prepuce. Some authorities claim that phimosis is a frequent predisposing factor, but this is denied by others. It frequently originates in a wart, and if a wart appears indurated at its base, the induration tending to spread to the surrounding tissues, it should be looked upon with suspicion. Epithelioma also develops upon chronic ulcers, such as venereal or simple herpetic ulcerations or the tertiary lesions of syphilis, as well as at the borders of old fistulæ. Malignant disease is most frequently seen after the fiftieth year, and is very rare before thirty, although it has been observed at eighteen years of age.

Fig. 859.

Epithelioma of the penis.

Symptoms.—The tumor when first seen is usually of considerable size, and may be of the papillomatous or of the ulcerative form. In the first case there is a cauliflower growth, with deep grooves between the papillomatous projections, from which exudes a foul discharge. (Fig. 859.) In the ulcerating form an indurated ulcer is seen, which frequently perforates the urethra, and may entirely destroy the glans. In the later stages, when the inguinal glands are involved, they too may ulcerate, and severe hemorrhage may take place from the femoral vessels. This glandular ulceration occurs early in the disease, and is undoubtedly the result of pyogenic infection taking place from the foul tumor on the penis in addition to the malignant contagion. The pressure of the enlarged glands may obstruct the return of blood and lymph and cause œdema of the lower extremities. In the early stages the patient is merely annoyed by the presence of the tumor and the foul discharge, but suffers comparatively little, for the pain is generally caused by secondary involvement of the glands in the groin or in the pelvis. Metastatic deposits are rare in this disease, but they have been observed in various organs, and we have seen extensive secondary growths in the lungs. The diagnosis in the initial stages is difficult, but the malignant nature of the disease should be suspected whenever an ulcer shows a tendency to bleed, when granulations appear which are rather brittle, and when the induration at the base of the ulcer tends to spread into the surrounding parts. The diagnosis should be made before the inguinal glands are enlarged, for a permanent cure will seldom be possible if operation is delayed until the lymphatics are diseased, and it is criminal to wait for enlarged glands to confirm the diagnosis. A microscopic examination of a small fragment of the suspected tissues should be made in all doubtful cases.

Treatment.—The only hope for cure lies in very early and radical operation. The entire organ should be sacrificed, at least up to the pubes,

no matter how superficial the disease may be, and the glands in the groin thoroughly removed at the same time. In extensive cases, and even when the tumor is small, if it has involved the corpora cavernosa, these bodies should be followed back to their attachments to the pubic bone and completely removed. The pubes and scrotum should be shaved and the parts sterilized before all of these operations.

Amputation.—The ordinary operation of amputation of the penis, which may be employed for mild cases or those of an uncertain diagnosis, is performed by cutting a circular flap of skin about an inch anterior to where it is proposed to divide the body of the organ. The circular flap is retracted, and, tension being made on the penis, the surgeon slowly divides the corpora on each side in turn, catching the main vessels before or immediately after division. The corpus spongiosum should be dissected from the corpora cavernosa anterior to the point of division of the latter and left somewhat longer. After the larger vessels are ligatured, further hemorrhage from the erectile tissue is prevented by two or three deep sutures, drawing the edges of the sheath together over the divided tissues. The circular flap may be united over the end of the stump in a transverse or in a vertical direction. In the latter case, which we consider the better method, the urethra is secured in the lower angle of the wound after having been slit up on its floor for at least half an inch in order to secure a wide meatus and to allow for subsequent contraction. If the transverse line of union is preferred, a puncture should be made in the lower flap at its base, and the end of the urethra secured in this opening, while the flaps are completely united above.

When amputation is performed for malignant disease, a complete and thorough dissection of the inguinal and femoral regions should be made at the same time, removing in one mass all glands, whether enlarged or not. We prefer to make this operation a part of the former, and extend the inguinal incisions well down to the root of the penis, so as to remove with the glands the fat and all the lymphatics running between that organ and the groin. The control of hemorrhage during amputation of the penis by an elastic bandage applied at the base has been recommended, but we have found it unnecessary, and it interferes with the complete removal of the organ. The secret of controlling the hemorrhage is the deliberate division of the parts, picking up the bleeding vessels with the artery clamps as soon as they are divided. Particular care must be taken that all hemorrhage is arrested before the wound is closed, as ligatures may loosen or slip off, or oozing points may give trouble a few hours after the operation.

Extirpation.—In the more complete operation, called extirpation of the penis, the corpora cavernosa are dissected from the rami of the pubes. Removal of the contents of both groins may be combined with it, the incisions in the groins being made to meet at the root of the penis, and the glands and fat being removed in one mass and left attached to the root of the organ. The penis is then circumscribed by a circular incision, dividing only the skin, and the scrotum is then split in two by rapid strokes with stout scissors following the raphe. By blunt dissection the testicles, remaining in their tunics, are readily separated, and the two halves of the scrotum

are held aside by assistants while the operator dissects out and lays bare the attachments of the corpora cavernosa to the pubic bone on each side. The root of the penis with the masses of lymphatic glands attached is then seized and drawn forward, and the suspensory ligament is divided so that the whole mass comes away from the pubes. The operator separates the attachments of the corpora cavernosa downward along the pubic bones with a periosteal elevator. The main vessels may give some difficulty, but are generally secured with ease with clamps, and can then be ligated. The penis then remains attached to the body only by the urethra, and this is divided. The stump of the urethra is split as described above, and the edges of the mucous membrane secured to the skin of the perineum just behind the scrotum by sutures. The edges of the skin are united throughout the wound, two or three deep sutures being placed in the middle line to hold the two halves of the scrotum in position.

When the disease has not attacked the corpus spongiosum, we have found it of advantage to the patient to dissect it from the cavernosa and to leave the urethra long enough to bring the end of that canal forward between the two halves of the scrotum and secure it upon the anterior surface of the latter. When the wound has healed, micturition is very much easier with the meatus in this position, because the patient can stand up, and by supporting the scrotum with one hand he has a natural funnel to direct the flow of urine beyond his feet. When the opening is in the perineum he is compelled to adopt the sitting posture in order to empty the bladder. If the penis is amputated at the pubic bone, the patient should carry a small funnel with him, which can be placed over the stump of the organ in order to direct the stream beyond the feet. The after-treatment of these cases presents nothing unusual. If the consent of the patient can be obtained, castration should always be performed at the same time as amputation of the penis, for sexual desire is sometimes troublesome afterwards, and it has been abundantly shown that the removal of the testicles late in life does not affect the character or mental qualities of the individual. The patient, however, will usually refuse to consent to further mutilation.

The percentage of cures after these operations for malignant disease of the penis is as yet uncertain, too few cases being on record that have been followed sufficiently long to determine this point. It would appear possible, however, to obtain cures by thorough operations in thirty or forty per cent. of the cases at the time when they are usually seen. Partial operations offer no hope whatever of a cure.

THE SCROTUM.

Injuries.—Injuries of the scrotum, with the exception of contusions, are not common, and these are remarkable for the size of the hæmatoma which may form on account of the rupture of large veins and the loose character of the cellular tissue, which allows great effusion of blood. The extravasation may be in the connective tissue, forming a hæmatocele of the scrotum, which frequently reaches the size of a man's head, and the ecchymosis may extend well up on the abdomen. The blood may also be confined in the tunica vaginalis, and then the tumor is smaller and the skin not ad-

herent. It may occupy both situations at once. The treatment of these injuries consists in the application of ice and compression in the early stages, followed by massage. Any abrasions present must be cleansed and dressed in the most careful and aseptic manner, lest cellulitis occur, with breaking down of the blood-clot. Should suppuration begin, a free incision must be made and the broken-down blood-clot turned out. Lacerated and incised wounds also need careful treatment for similar reasons.

Inflammations.—The tissues of the scrotum are unusually liable to infection and slough very readily, but are readily restored, the entire skin of the scrotum being reproduced in three or four months by new growth and by cicatricial contraction, which draws the skin of the neighboring parts over the testicles. The scrotum is liable to the ordinary diseases of the skin, and they are unusually difficult to treat because of the natural moisture and constant friction.

Tumors.—Tumors appear on the skin here as elsewhere, and **epithelioma** is very common in persons of uncleanly habits, often developing upon a chronic eczema or psoriasis which has been neglected. It has been clearly shown that chimney-sweeps' cancer, which is simply an epithelioma of the scrotum, is entirely dependent upon uncleanly habits, for the disease was extremely common among the chimney-sweeps of London while the same class of men in Belgium were free from it. The irritation of the coal-tar products in the soot, aided by the lack of cleanliness, caused the malignant disease, and similar epitheliomata have been observed elsewhere on the body in the workmen in paraffin factories. **Fatty tumors** develop in the scrotum, especially in connection with the cord, and may attain a very large size and entirely surround the testicle. **Elephantiasis** of the scrotum is common in connection with elephantiasis of the penis and lower extremities, and is due to the same causes. In this country we rarely see the elephantiasis due to the filaria parasite, but similar changes are produced by chronic inflammatory fibrous thickening of the tissues, when œdema from any cause persists for a long time.

THE TESTICLE.

Congenital Anomalies.—The congenital abnormalities of the testicles consist almost entirely in variations from their normal position, although in rare cases complete absence of at least one of the glands has been observed. The testicle is sometimes found **reversed** in its position in the scrotum, the epididymis being turned forward and the tunica vaginalis behind it, so that the gland would be in danger of injury when tapping a hydrocele.

Normal Descent of the Testicle.—In early fœtal life the testicle occupies a position within the abdomen near the posterior crest of the ilium, in close relation to the kidney, the latter ascending as development proceeds, and the testicle descending towards the inguinal ring. A fibrous band containing some muscular fibres, known as the gubernaculum, passes from the lower end of the testicle to the inguinal ring, and is divided into three branches, one of which goes to the bottom of the scrotum, one to the perineum, and one to the femoral region, the first being usually the most powerful. The exact mechanics of the descent of the testicle are not under-

stood, but as it proceeds the gubernaculum shortens, and the latter is supposed to guide the gland to its proper position. The testicle enters the inguinal canal by the internal ring, traverses its whole extent, and passes into the scrotum through the external ring, bringing down the spermatic cord and leaving it in its track. As the testicle advances it pushes before it a pouch of peritoneum which covers its anterior surface and is known as the vaginal process. When the testicle has reached the scrotum the neck of this process of peritoneum is completely obliterated by natural contraction, and the serous lining of the abdomen, seen from within, normally presents a flat surface at the internal ring, with no trace of the previous pouch. The lower end of the protruded serous membrane forms the tunica vaginalis, surrounding the testicle and extending a variable distance up the cord towards the external ring. A thorough understanding of this method of descent is also important for a proper comprehension of the varieties of hernia.

Ectopic and Undescended Testicle.—The testicle should have reached the scrotum and the vaginal process should be closed at birth. The descent of the testicle may, however, be delayed so that it will lie at the external ring or in the inguinal canal until much later, and in some cases it is retained there, or even within the abdomen, throughout life. In still other cases it may be found lodged in the perineum or in the groin (Fig. 860), probably because it has followed the fibres of the gubernaculum leading thither. When the testicle remains within the abdomen it is said to be retained or undescended. When it is not in its natural position, but has passed out of the abdomen, it is said to be ectopic. An ectopic or retained testicle is usually more or less atrophic or undeveloped, being composed largely of connective tissue. A retained testicle is more likely to be well developed than an ectopic one, but even in such cases it is very liable to malignant disease. Inflammation of an ectopic testicle, especially if it lies in the inguinal canal, is apt to be very severe and to cause great pain on account of the additional tension due to its confinement by strong fibrous structures. The testicle in this position is also liable to malignant disease. Undescended testis is frequently combined with hernia, as has already been mentioned.

FIG. 860.

Ectopic testicle. The left testicle is on the fascia lata below Poupart's ligament, and the right half of the scrotum contains the right testicle and an inguinal hernia.

Treatment.—An ectopic testicle which causes no symptoms is best left untouched unless there appears to be a reasonable chance of placing it in the scrotum. If inflamed, or threatening to form a tumor, it should be re-

moved. To replace the organ in the scrotum, it is exposed by free incision and dissected out, the cord being drawn out as much as possible. The gland is then placed in a bed made for it in the scrotum, and secured by sutures passing through its capsule. In these cases the corresponding half of the scrotum is liable to be small and atrophic, but it is usually large enough to contain the small gland. When the testicle is situated at the internal ring or just within the inguinal canal, it can sometimes be pushed downward by the pressure of a truss properly applied. The pad should have a slight concavity on the end for the testicle, and should be worn day and night. These means of treatment are, however, very unsatisfactory in extreme cases, for the testicle is so small as to be of little value, and the necessary manipulation is apt to impair its vitality still further. If the patient's consent can be obtained and the other testicle is in good condition, it is wiser to sacrifice the ectopic gland at once. For the testicle retained in the abdomen nothing can be done, but it should be kept under observation, in order that it may be removed promptly at the first sign of enlargement, on account of the tendency to malignant disease.

Injuries.—Wounds of the testicle are very rare and scarcely need mention. **Contusions,** however, are exceedingly common, and are followed, as a rule, by extensive hæmatocele, which may result in complete disorganization of the gland and be followed by its complete atrophy. The injury to the gland will often be masked at first by hæmatocele of the scrotum or of the tunica vaginalis. Hæmatocele of the testicle may be the result of severe muscular effort, although the explanation of these cases is difficult. The most widely accepted theory is that the intense contraction of the cremaster muscles during violent muscular exertion compresses the testicle so strongly against the pubic arch or the inguinal ring as to rupture a blood-vessel in the gland. It is probable, however, that in many cases some sudden and severe pressure of the clothing occasions the injury. The symptoms of a severe contusion of the testicle are a feeling of faintness, caused by the pressure, like the well-known *testicular sensation,* followed by intense pain in the testicle or a dull, heavy ache, which may become throbbing and be accompanied by considerable lumbar pain. The injury is marked by very severe shock, which has sometimes caused death.

Treatment.—The treatment of these cases consists of rest in bed, the scrotum being supported on a platform made of a bandage or a towel stretched across the thighs, and the application of an ice-bag. In the later stages careful massage and the application of an elastic bandage will hasten the absorption of the effusion, and a suspensory should be worn afterwards until the testicle has reached its normal size. The preservation of the function of the organ is best assured by complete rest during the early stages, so that the blood-clot may be absorbed as rapidly as possible.

Torsion.—A peculiar displacement of the testicle, known as torsion, consisting of rotation, with twisting of the cord, sometimes occurs. It is rendered possible by an abnormal arrangement of the tunica vaginalis, which forms a sort of mesentery to the testicle and cord in these cases and leaves the gland much freer in its movements within the cavity than is natural, and a sudden movement may rotate the testicle upon its long axis, twisting

the cord and suspending the circulation. In slight cases a momentary pain is felt, but the testicle soon returns to its position and the symptoms disappear. In severe cases, however, the testicle does not return, and the twist may increase, the circulation may be cut off entirely, and gangrene of the gland result. When the symptoms are severe, spontaneous reduction does not take place.

Treatment.—The testicle should be exposed by an incision into the tunica vaginalis and the twist reduced if the gland is not necrotic, but if gangrene threatens, the testicle should be removed at once. In cases in which slight attacks occur repeatedly, the testicle may be secured in place by a suture, the needle picking up the skin of the scrotum and the anterior surface of the capsule of the testicle, either catgut or fine silk being used. It is not necessary to make an incision for this purpose, and the adhesion produced by a single stitch should be sufficient, for we have followed a case of this kind for some time without any relapse.

Dislocation.—A rare accident is traumatic dislocation of the testicle, the latter being driven from its place in the scrotum into the subcutaneous tissue in front of the pubes, or on the side, or even into the sheath of the penis. If the testicle cannot be restored by manipulation, it should be exposed by incision and replaced or removed.

Hernia testis and **fungus testis** are terms applied to a protrusion of the substance of the testicle through an opening in the tunica albuginea, or to exuberant granulations forming upon the latter. It may follow an injury in rare cases, but is most frequently the result of ulceration, either tuberculous or syphilitic.

Treatment.—The superficial form can be treated by excising or cauterizing the granulations and strapping the testicle. When the substance of the testicle protrudes, the projecting part is to be excised with its base, making a wedge-shaped wound, and the tunica united by sutures. In extreme cases, when nearly the entire testicle protrudes or has been destroyed, castration is the proper treatment. The protrusion of a malignant tumor must not be confused with hernia testis.

Inflammations.—Inflammation of the body of the testicle is called *orchitis*, and that of the epididymis *epididymitis*. The inflammation may be acute or chronic, and in some cases results in suppuration. It may be due to **gonorrhœa**, to **metastasis in mumps** or epidemic parotitis or in **pyæmia**, to **tuberculosis**, and to **syphilis.** Orchitis is also observed in typhoid and malarial fevers and in gout. Gonorrheal inflammation may be observed in the acute stage, and may even follow the passage of a sound for any purpose years after. (See section on Gonorrhœa.)

The **inflammation of mumps** is usually an orchitis, and causes a tender swelling of the gland of moderate size, the pain not being so acute as in the gonorrhœal form. In some cases, however, there are high fever and great constitutional disturbance. This inflammation runs a course of a week or a fortnight, gradually subsiding, and generally has no evil consequences, although atrophy has occasionally been observed. The treatment consists of rest in bed, laxatives, light diet, and the application of an ice-bag to the parts. A suspensory bandage should be used when the patient is up and

about. **Metastatic abscesses** develop in the testicle in cases of pyæmia, and have the usual chronic character of abscesses of this nature, the gland being moderately enlarged and tender, but without great pain, and giving no distinct evidence of pus until quite late. The treatment should consist in incision as soon as fluctuation can be demonstrated.

Tuberculosis of the testicle is generally due to blood infection, being the primary lesion in tuberculosis of the male genitals, but in some cases it is secondary to tuberculosis of the prostate or other parts, the infection reaching the testicle by the vas deferens. The pathological changes consist in the appearance of tubercles, which become cheesy and calcareous or break down into cold abscesses. They almost invariably appear first in the epididymis. Rarely a miliary form is observed. **Symptoms.**—The disease may be acute or chronic in its beginning and course, but it is usually subacute. The patient is seized with a slight pain in the testicle and a slight swelling appears in the epididymis, with which some hydrocele may be associated. An abscess of small size slowly forms without much pain and then discharges, leaving a sinus. The symptoms disappear, but an indurated nodule and the sinus persist. In some cases the attack may begin as acutely as a gonorrhœal epididymitis, while in others a small painless induration is observed in the epididymis, which causes no symptoms, but steadily increases in size, and at the end of some months may produce a small abscess. A nodular or uniform infiltration of the spermatic cord is frequently observed. If the disease is limited to the testicle the patient will suffer very little in general health, but, as a rule, it is found associated with similar disease of the prostate and seminal vesicles. The disease attacks young adults from twenty to thirty years of age, and not infrequently follows an acute attack of gonorrhœa, so that in the acute cases its **diagnosis** from gonorrhœal epididymitis may be very difficult. In the early stages the small, hard nodules resemble those left by a gonorrhœal epididymitis, but the latter are usually in the globus minor, while the former are apt to occupy the globus major. The history of the presence of tuberculous nodules in the prostate will assist in the diagnosis. The tendency to break down into abscesses will distinguish the rapidly growing forms from malignant tumors. The diagnosis of tuberculous disease depends upon the combination of induration with spots of softening, and the presence of sinuses or sluggish abscesses, while rectal examination should never be omitted, for evidences of prostatic or seminal vesical disease may be obtained in the majority of cases. **Prognosis.**—The course of the disease is usually very slow, even in those cases which begin acutely, and there can be no question that spontaneous recovery takes place in many instances.

Treatment.—Recovery sometimes follows proper attention to diet, and a life in the open air in a good climate, with freedom from care and responsibility. The administration of tonics, cod-liver oil, and creosote may also be tried. If the disease in the testicle is very troublesome, with profuse discharge, many sinuses, or considerable pain, the organ should be removed. It may also be removed with the hope of a radical cure when there is no advanced disease elsewhere in the genital organs, but some small deposit is very likely to be felt in the prostate or the seminal vesicles. Partial opera-

tions, limited to removal of the tuberculous mass by the curette or excision, may result in a cure, and primary union may often be obtained in such wounds. We have operated upon a number of cases in which the testicle could be partially preserved, and, even although the destruction of the epididymis and its ducts was considerable, some of these patients have lived active sexual lives afterwards. The decision of this question will vary with the individual surgeon, but our personal preference is for the removal of entirely disorganized testicles in any case, and removal of one testicle when that is the only discoverable tuberculous lesion in the body, or even when there is a slight lesion of one lung. Tuberculosis of the prostate and seminal vesicles, if extensive enough to be recognized, usually contra-indicates castration for the sake of a radical cure. In all other cases partial operations are to be attempted. In every case the advantages of a healthy life in a good climate should be sought for by the patient.

Syphilitic disease of the testicle has been sufficiently described elsewhere. It is almost invariably an orchitis, and produces large, hard, smooth tumors, heavy but not painful or tender, and of very slow growth.

Tumors.—Benign tumors of the testicle are rare, but **fibroma, myoma, lipoma,** and **chondroma** have been reported, the latter being the most common. These tumors are either of such small size that they are of no clinical importance or come to the surgeon with no other symptoms than the weight of the heavy tumor which inconveniences the patient. The large tumors are almost invariably chondroma, and are undoubtedly due to the development of congenitally misplaced fragments of fœtal tissues. They are often mixed in character, and tend to sarcomatous degeneration. Small **myomata,** both of striped and unstriped muscular fibres, making nodules from the size of a hazel-nut to a walnut, have been observed attached to the epididymis, where, in their early stages, they may be mistaken for a chronic epididymitis. Small **lipomata** have been observed in the substance of the testicle, but most of the cases of lipoma reported are, properly speaking, lipoma of the cord, having developed from the cord and surrounded the testicle, which is often found practically unchanged in the centre of a huge mass of fat. **Cysts.**—**Large cysts** of the testicle are almost invariably a part of sarcomatous disease, and require removal of the testicle. Small **serous cysts** with thin walls, sessile or pedunculated, often multiple, are found connected with the epididymis, containing a thin serous fluid, and very rarely spermatozoa. They occur after middle life, and never attain a diameter of over half an inch. They appear to be similar in pathology to the involution cysts of the mamma, and are of little importance. **Spermatic cysts** or **spermatoceles** are larger than these subserous cysts, and attain a diameter of two inches or more. They are sometimes multilocular, also originate from the epididymis, usually between its upper part and the body of the testicle, and contain a milky fluid with spermatozoa. They are either retention cysts or arise from some fœtal remains of testicular substance, such as the organ of Giraldès. The treatment of these cysts consists in evacuation with a hypodermic syringe, and, if a second treatment is necessary, the injection of a drop of iodine or half a drop of carbolic acid

should be tried. Dermoid cysts of the testicle have been reported, but are rare.

Malignant tumors of the testicle may be either sarcoma or carcinoma. **Sarcoma** of the testicle appears at any age, although it is most frequent in early adult life. It begins in the body of the organ, and all histological varieties of the tumor are found. It presents a rapidly growing tumor, which retains the shape of the testicle, but is apt to be of varying consistency in different parts, being partly hard and partly soft, with a tendency to the production of cysts or cartilaginous plates. The scrotum is evenly distended over the mass, and not adherent even when it attains a large size. The cord is evenly thickened and its vessels swollen, and the inguinal glands are enlarged more frequently than is usual in sarcoma elsewhere. The softer tumors may grow quite rapidly, and both testicles may be involved. They are apt to break down, and, if the skin of the scrotum sloughs, the tumor projects through the opening. The firmer tumors progress much more slowly. The patient at first complains only of the weight and size of the tumor, but in the later stages pain sets in, and there may be symptoms from metastatic deposits in other parts of the body. The only **treatment** is removal by castration.

Carcinoma of the testicle usually originates from the body of the organ, and is almost invariably composed of spheroidal cells. It occurs comparatively early in life, before the forty-fifth year, and even in childhood. It is a more slowly growing tumor than sarcoma, is much softer to the touch, and may feel as elastic as a hydrocele. The skin becomes adherent early, and ulceration sets in after a year's duration. The tumor at this time is usually as large as a man's fist, and the pelvic and inguinal glands become enlarged within the first year. The patient complains of pain more than in sarcoma, and pain is also felt in the lumbar region, with a dull aching in the groin. With the infection of the glands severe neuralgic pains in the lower extremities set in, and the venous circulation may be obstructed. The treatment is early and thorough operation, removing not only the testicle but as much of the cord as possible, for it is usually involved in the process.

Diagnosis of Tumors.—The diagnosis of tumors of the testicle is made by their weight when lifted in the hand, which is much greater than hernia or hydrocele, by their lack of translucency, by their lack of impulse on coughing, and by the account of the patient that the tumor first appeared in the lower part of the scrotum, or even that it originated in the testicle. Tumors of the scrotum are differentiated by ascertaining that the testicle is not involved, and the diagnosis of hernia and hydrocele is given in the chapters on those conditions.

Castration.—The operation for the removal of the testicle is a simple one, the skin being incised longitudinally over the gland and the latter shelled out of the tissues of the scrotum, removing the tunica vaginalis, in cases of tumor, as it is advisable to make as wide an excision of the neoplasm as possible. The testicle and tunica being shelled out of their bed, the cord is followed up well to the external inguinal ring, and if it be involved even at that point the inguinal canal should be opened and the cord drawn down, if possible, until a healthy part is reached. A ligature is made to transfix

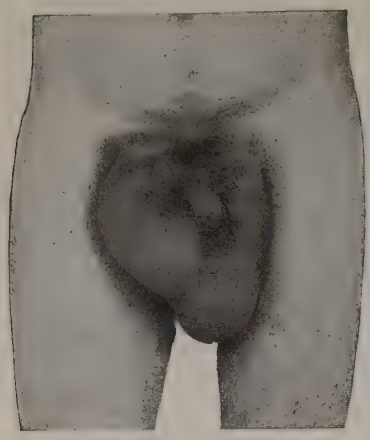
the cord, and is then passed around it and tied and the cord divided. The spermatic artery and the artery of the vas are then separately ligated. The canal of the vas is touched with the cautery to destroy the mucous membrane, and the wound is closed with sutures.

Hydrocele.—Hydrocele is the distention of the serous sac surrounding the testicle or cord with a serous effusion. In rare cases the fluid is milky, like chyle, from fatty granules suspended in it, owing to lymphatic obstruction from filaria disease or a wounded lymphatic vessel. Hydroceles having opalescent or milky contents may contain spermatozoa coming from the rupture of spermatoceles into the sac. The changes in the tunica vaginalis in cases of hydrocele consist in thickening of the walls by a deposit of fibrin and an overgrowth of the endothelial cells. Adhesions may take place between different parts of the membranes, forming cavities, which in their turn become dilated, so that a multilocular hydrocele is formed. In other cases it is evident that the multilocular hydroceles have originated from congenital subdivisions of the tunica vaginalis. Hydrocele may be acute or chronic. **Acute hydrocele** accompanies inflammations of the testicle, seldom attaining a large size, but suppurating in rare cases. **Chronic hydrocele** may occupy the cavity of the **tunica vaginalis**, or the remains of the **funicular process** along the cord, or may surround an **ectopic testicle** in any situation. When the funicular process is shut off from the vaginal cavity below and from the peritoneum above, and serum accumulates, cysts may be formed anywhere between the internal inguinal ring and the testicle, which are known as **encysted hydroceles of the cord.** If the peritoneal orifice of the process remains open but it is shut off from the tunica vaginalis below, a **congenital hydrocele of the cord** may form—a very rare condition. The encysted hydroceles are rather small, but may extend well up into the inguinal canal. The testicle is felt free below them, but the irreducibility and translucency of the tumor make the diagnosis from hernia simple. There may be more than one of these cysts. As a rule, they are thin-walled, but we have seen one case with a wall as thick as the tunica vaginalis. They are most common in children, and probably often disappear spontaneously before adult life. They should be aspirated, and if they return they should be treated by carbolic acid injection, by incision, or by excision, according to the methods described below.

Hydrocele of the Tunica Vaginalis.—The most common variety of hydrocele is that of the tunica vaginalis. In some cases it has a continuation into the inguinal canal in the funicular process, which has closed above but remained open towards the tunica vaginalis; this condition is called **infantile hydrocele.** In rare instances the sac may even extend into the abdomen and form a cyst there in connection with the tunica, known by the name of **hydrocele en bis-sac.** Hydrocele is found at all ages, but is most frequent at the two extremes of life. In some cases the funicular canal which connects the peritoneum with the tunica vaginalis in the fœtus remains open, and any fluid confined in the peritoneum will descend into the cavity of the latter. Hydroceles thus formed are called **congenital,** and are reducible, the contents returning into the abdomen when the patient lies down or when the sac is compressed. It is said that tuberculosis of the perito-

neum and tuberculosis of the tunica vaginalis are frequently associated in these cases, on account of the free communication between the cavities. A serous effusion into the tunica is a frequent accompaniment to inflammation of the testicles, whether it be gonorrhœal, traumatic, or tubercular, but this symptomatic hydrocele seldom reaches a size demanding treatment unless the tension is so great as to cause pain and necessitate aspiration.

Fig. 861.



Double hydrocele.

The actual beginning of the accumulation of fluid in the sac cannot be ascertained in the great majority of cases of hydrocele. Without pain or other sensations, the patient notices that one side of the scrotum is a little fuller than the other, and that the swelling has begun at the bottom of the scrotum about the testicle. The swelling at first is soft, but soon becomes tense, and increases in size, until in some cases the scrotum extends nearly to the knees. The increase is usually very slow, and a year is required for the swelling to attain the size of a man's fist. The patient is disturbed only by its weight and bulk, although in rare instances the sac may rupture or suppurate, and he seldom consults the surgeon until it has been in existence for some time. In about one-fifth of the cases there is a hydrocele on both sides. (Fig. 861.)

Diagnosis.—Examination shows a tense or fluctuating swelling, occupying one-half of the scrotum, rather pear-shaped, with no impulse on coughing, and the tumor weighed in the hand feels rather light.

If a light is held close to one side of the scrotum, the swelling is found to be translucent. As a rule, it will be necessary to use an opaque tube of pasteboard or other material in order to shut out the diffused light, or even to make the test in a dark room, to obtain satisfactory results if the sac is thick. The translucency of a hydrocele varies according to the thickness of the sac-wall, and when it is very translucent the shadow of the testicle is distinctly seen. The normal position of the testicle is at the lower back part of the sac, the natural position of the epididymis and of the cord being posterior. In some cases, however, the gland is congenitally turned in the opposite direction, the epididymis being in front and the cord running down the anterior surface of the sac. Occasionally the testicle can be felt through the sac wall. The diagnosis of hydrocele from hernia and from tumors of the testicle and scrotum has been fully given in the chapter on hernia. It should be borne in mind that hydrocele and hernia are often associated. In the ordinary cases no difficulty should be met with in making the diagnosis, for the symptom of translucency is not present in hernia, hæmatocele, or any other scrotal tumor, except in the very thin-walled intestinal hernia of infants. The last named condition is not likely to be mistaken for hydrocele, because only an irreducible hernia would resemble

hydrocele, and an irreducible hernia almost invariably contains omentum, and is therefore opaque.

Treatment.—*Aspiration and Injection.*—The first attempt at the treatment of hydrocele should always be aspiration and injection of carbolic acid. Cutting operations should be reserved for severe cases, as the injection treatment will cure at least three-fourths of the cases. In very young children mere aspiration of the contents and scratching the inside of the sac with the point of the needle will often suffice for a cure. To *tap a hydrocele* the surgeon takes the tumor in his left hand and the trocar in his right, his finger being placed on the trocar half an inch from the point, in order to prevent too deep penetration. The point of the trocar is placed lightly on the skin over the most prominent part of the tumor, about one-third of the distance from the bottom to the top, and then with a sudden thrust the instrument is driven through the sac-wall. If it is intended to *inject carbolic acid*, the needle of the hypodermic syringe, containing from ten to twenty drops of pure carbolic acid, liquefied with glycerin, is inserted into the sac just above where the trocar enters, and the points of the two instruments are made to touch each other in the cavity of the sac, in order to prove that the point of the hypodermic needle is really in the hydrocele. The trocar is then withdrawn, and the fluid flows out of the canula, the fingers squeezing the sac together so as to evacuate the last drops, but the needle must be kept constantly in contact with the canula. The canula is then withdrawn, the carbolic acid injected, and the syringe also withdrawn. The pain of the proceeding is slight if the trocar be sharp, but in some instances there is considerable burning from the carbolic acid. The sac is to be rubbed between the hands, so as to diffuse the acid equally over its internal surface.

Some surgeons prefer the *injection of iodine*, but its action is much more painful and no more certain than that of carbolic acid. When iodine is employed, from half an ounce to an ounce of the fluid is injected through the canula, retained a moment, and then allowed to escape, or a less quantity is used and allowed to remain in the sac. On account of the pain it is generally necessary to use cocaine before making the injection, injecting a two per cent. solution, and allowing it to escape after being in the sac two or three minutes. This is an added danger, for cocaine poisoning has followed this procedure more than once, as it is difficult to ascertain that all of the fluid has escaped.

After the injection of either reagent the fluid reaccumulates and the patient may be uncomfortable for a few hours, but within a week the hydrocele becomes smaller, and soon disappears. In some cases a second injection is necessary, and in any case in which absorption does not begin in the first week it is well to draw off a couple of drachms of the fluid, in order to lessen the tension and assist absorption. If there is much pain, the patient should be kept in bed, the scrotum elevated upon a folded towel, an ice-bag applied, and morphine administered. Full aseptic precautions must be taken in preparing the skin and boiling the instruments, in order to avoid infection, which would result in suppuration of the sac. If it is found on aspiration that the sac is multilocular, each sac must be

evacuated and injected in turn, only a very small quantity of the carbolic acid being thrown into each cavity. For a hydrocele the size of a man's fist fifteen drops will usually be sufficient. In smaller hydroceles a less quantity should be employed, and in infants only from two to five drops. In very large hydroceles the sac is to be emptied first and the injection postponed until it refills to the size of a man's fist. The only dangers to be feared in this operation are septic infection and the injection of the carbolic acid into the tissues. The first of these can be avoided by asepsis, and the second by making sure that the needle is kept in contact with the canula. A hydrocele with a very thick wall and some multilocular hydroceles will resist the treatment by injection and require cutting operations.

Incision, or Volkmann's operation, consists in open incision of the sac, the incision being made over its anterior surface in its entire length. The fluid is allowed to escape, a drainage-tube or strip of gauze is placed in the sac, and a continuous suture is made, uniting the skin to the edge of the sac-wall entirely around the opening, thus covering in all the raw tissues. A couple of deep sutures are then passed through the scrotum and wall of the sac so as to hold the two edges in apposition, and a firm dressing is applied in such a manner as to press the sides of the sac together over the testicle. Adhesion of the two walls of the sac takes place, the exposure to the air being sufficient to excite the necessary irritation. In a week or ten days the wound is reduced to a granulating strip, but this may require five or six weeks to heal completely. The patient need not be confined to bed after the first week, but the slow healing of the wound is an objection to the treatment.

Extirpation.—Von Bergmann recommended the extirpation of the sac of the hydrocele, exposing it by an anterior incision and stripping it out of its bed in the scrotum by blunt dissection as far back as the junction of the serous membrane to the testicle and the cord. The sac is opened and its wall cut away from the testicle close to its attachments. There may be a little hemorrhage from the scrotal veins and troublesome oozing from the small vessels at the attachment of the sac near the epididymis. In simple cases the operation is very easy, but in the long-standing cases with very thick sacs, for which the operation is really necessary, there may be numerous adhesions and considerable difficulty in cutting away the sac from the testicle. When hemorrhage has been controlled, the scrotal tissues are united over the testicle with two or three mattress sutures and a continuous suture of the skin. Union takes place in a week or ten days, during which the patient should be kept in bed. Thorough as this operation is, recurrence has been known to follow it, as well as Volkmann's, arising from the serous membrane left on the outer surface of the testicle. Both of these operations may be done with the aid of cocaine, but a general anæsthetic is preferable unless the patient be unusually phlegmatic. Perfect asepsis must be maintained, as any infection in the loose tissues of the scrotum would be fatal to primary union, and might have troublesome and dangerous consequences. These operative measures should be limited to cases in which the walls of the hydrocele are very thick, or in which some complication exists, such

as a hernia, which may be treated at the same time. It is also suited to cases of doubtful diagnosis, when tuberculosis or a tumor of the testicle is suspected.

INJURIES AND DISEASES OF THE SPERMATIC CORD.

Injuries.—A wound of the cord with division of the vas deferens may result in the formation of a fistula with external discharge of the semen. Torsion of the cord has already been described in the section on the testicle.

Tumors of the spermatic cord are too rare to require description.

Varicocele.—The most common disease of the spermatic cord is varicose dilatation of its veins, a condition known as varicocele. The dilated veins sometimes form a tumor of considerable size, extending from the inguinal ring to the testicle, and feeling like a bunch of angle-worms. The vessels may have thickened and hardened walls or may be very thin and soft to the touch. When the patient lies down the veins are emptied and the tumor disappears. A varicose condition of the veins of the scrotum is usually associated with varicocele of long standing. The scrotum is elongated, and the testicle upon the affected side hangs lower than the other. (Fig. 862.) The testicle in cases of long standing feels very soft and relaxed, sometimes undergoing atrophy, and if the varicocele is cured the testicle may become even smaller, a large part of its previous bulk having been made up of the swollen veins. This atrophy, however, may be temporary, and the gland may regain its normal size. Varicocele attacks both sides of the scrotum in about one-twelfth of the cases, and in about the same proportion of the unilateral cases it occurs on the right side. The greater frequency of varicocele on the left side has been ascribed to certain anatomical facts—that the spermatic vein is crossed by the sigmoid flexure, that it receives branches from the colic veins, and that it enters the left renal vein at right angles to its course. The predisposing causes of varicocele are a sedentary life, neglect of the bowels, and sexual overstimulation, especially soon after puberty. It is a disease of early adult life, and usually disappears in middle age. The patients are apt to be young men of relaxed fibre, and are often neurasthenic, but varicocele may occur in very vigorous men. The patient feels a dragging sensation in the testicle, and complains of its weight, but otherwise the health is not affected, although the sexual powers are apt to be slightly impaired.

Fig. 862.

Varicocele.

Treatment.—Slight varicocele needs no treatment but the wearing of a suspensory bandage to support the testicle, a change from sedentary habits to active out-door life, and the avoidance of everything which tends to produce

sexual excitement. More serious cases may be treated by ligation of the veins, either subcutaneously or in an open wound, or by shortening of the scrotum. It may, however, be necessary to operate in some individuals when the disease is slight, because they are hypochondriacal or because they are liable to rejection in the physical examination required before admission to military or other services.

Subcutaneous ligation of the veins is executed as follows. The hair should be shaved from the scrotum and the pubes around the point intended for operation for a distance of two or three inches. The surgeon takes the root of the scrotum between his fingers and feels the cord, recognizing the vas deferens by its hardness, separating it from the other parts of the cord as far as possible, and holding it towards the median line, while the veins and other tissues are pushed to the outer side of the scrotal fold. The vas being held out of the way by the thumb-nail, a needle carrying fine silk or catgut is made to transfix the scrotum close to the thumb. It is then re-entered at the point of exit, and carried subcutaneously to the outer side of the veins and around them, and made to issue from the original puncture of entrance in front. The thread is drawn tight, pulled away from the skin on all sides, and tied with a square knot. The ends are cut short and the knot allowed to slip under the skin. The object of this operation is to secure in the ligature all the tissues of the cord except the vas deferens. Another ligature should be applied lower down in bad cases. If the operation has been properly performed, all the vessels will be ligated except the artery of the vas, which lies close to that duct, and possibly one or two small veins in its neighborhood. The ligated veins become obliterated. The patient should be kept quiet for a few days, to make sure that the asepsis has been successful, and to avoid any accident from thrombosis originating at the point of ligature. This operation will cure a large majority of the cases, and it is so simple that it scarcely needs an anæsthetic, although in nervous patients the injection of a drop of cocaine may be advisable. There is little or no pain afterwards, although in some cases the testicle becomes swollen. Although the spermatic artery is intentionally included in the ligature, atrophy of the testicle does not follow the procedure, but if the testicle is very small the patient's attention should be drawn to that fact before the operation.

Incision and Resection.—A more certain method is the operation by open incision, which is performed at the same point, the skin being incised for the length of an inch, the cord drawn out of the wound, including all the vessels in its neighborhood, and a blunt instrument passed beneath it. The operator separates the vas and its adherent artery from the other vessels, and the latter are surrounded by two ligatures about an inch apart and divided between the ligatures. A separate ligature may be applied to the proximal end of the spermatic artery if it is visible in the stump. If the cord is long, an inch or more may be cut away between the ligatures, an end of each ligature tied together to shorten the cord, and the wound closed with a few stitches. A compressive dressing should be applied, as it will prevent swelling of the testicle, relieve pain, and keep the patient quieter.

Ablation of the Scrotum.—The scrotum has been amputated for varicocele, and fair results have been claimed, but in our experience it is insufficient without ligature of the veins. For this operation the patient is anæsthetized, although it may also be done with cocaine. The scrotum is held up by the raphe by an assistant while the surgeon adjusts to it a long, slender curved clamp below the testicles, so as to compress it laterally. To prevent the clamp from slipping, it is well to pass two or three needles through the scrotum on the outer side of the clamp. The scrotum is then cut away a quarter of an inch below the clamp, and half a dozen mattress sutures inserted to hold the parts in apposition. A continuous suture of fine catgut is then run over the edge, bringing the skin-edges together. This apposition may be difficult with the clamp in place, in which case the sutures may be left loose and drawn up after the instrument has been removed. The use of the clamp is of assistance to the operator, as it makes the operation a bloodless one and holds the lax parts firmly in position, and it also draws all the layers of the scrotal tissues into the wound, and thus the natural raphe is preserved, whereas if only skin-union is obtained it easily stretches afterwards. The clamp may, however, be dispensed with if half a dozen mattress sutures are applied while an assistant holds up the scrotum by the raphe. These sutures must be placed just within the line of the proposed incision, and must not be tied too tightly, for fear of gangrene of the edges of the wound. It need scarcely be noted that thorough shaving and preliminary sterilization of the parts are necessary, with a firm occlusive dressing afterwards, if primary union is to be obtained. The latter is particularly difficult to achieve in the scrotum.

DISEASES OF THE PROSTATE.

Inflammation.—The prostate is liable to certain inflammations, which may be either catarrhal or suppurative, and are pyogenic, gonorrhœal, or tuberculous in origin.

Catarrhal prostatitis, often called **prostatorrhœa,** may be due to excessive sexual excitement (although it is more commonly seen as the result of masturbation than of coition), to infection by unclean instruments, or to mechanical irritation by riding astride narrow seats. The symptoms of catarrhal prostatitis are a sensation of weight and discomfort in the perineum, rarely amounting to actual pain, with hyperæsthesia of the prostatic urethra, and an increase in the frequency of micturition. There is a feeling of weakness in the lumbar region, sometimes a dull, aching pain. A slight mucous discharge also shows itself by gluing together the lips of the meatus in the morning, and a few drops of the fluid may be passed at stool, or an unusual amount of this discharge may take place during sexual excitement. A slight discharge of prostatic fluid during sexual excitement is natural, and even at stool it is not necessarily abnormal, but the quantity is increased in catarrhal prostatitis. It is this symptom which is usually called spermatorrhœa by the laity, but the fluid contains no spermatozoa. By *expression* of the prostate, which is carried out by inserting one finger in the rectum and making pressure upon the gland from behind, a considerable amount of this fluid can sometimes be obtained for examination, and it con-

tains characteristic needle-shaped crystals, somewhat resembling the simple phosphatic crystals in the urine.

Treatment.—Complete abstinence even from sexual thoughts should be advised, with a regular life and plenty of out-door exercise as the foundation of all treatment. The occasional passage of a cold urethral sound of large size, introduced fully into the bladder, so as to straighten the urethral curve, is very useful. This treatment is also to be recommended as an aid in lessening the sexual discomfort of men who are beginning a celibate life, having recently been separated from their wives after active marital relations—a class of cases in which mere hyperæmia of the prostate causes symptoms similar to those of catarrhal prostatitis. Occasionally applications of nitrate of silver to the prostatic urethra relieve the congestion and lessen the irritation and tenderness. The applications are made by the Ultzmann syringe (Fig. 863), 1 to 10 drops of a solution of nitrate of silver, 10 grains to the ounce, being injected into the prostatic urethra, and the patient being directed to pass water immediately or after the lapse of two or three minutes, according to the amount of stimulation deemed necessary. The injection should alternate with the use of the sound once or twice a week in order to produce the best effect.

Fig. 863.

Ultzmann prostatic syringe.

Gonorrhœal Prostatitis.—When gonorrhœa penetrates to the deep urethra it involves the prostate, and may leave a chronic gleety or muco purulent discharge which is exceedingly difficult to cure. There will be shreds in the first part of the urine passed, and gonococci may be found in them. In this form of gonorrhœal prostatitis the sexual irritability is lessened instead of increased, but the pain and tenderness may be greater than in the catarrhal form, and abscess occasionally results, the previous history and the purulent discharge distinguishing it from the catarrhal form. The **treatment** consists in deep injections, which may be given by the Ultzmann method, by passing a metal catheter with long slits at the sides near the tip, so that it shall be within the grasp of the sphincter, and then injecting a considerable quantity of warm sulphocarbolate of zinc solution (alum, sulphate of zinc, carbolic acid, each, 1 part; distilled water, 200 to 500 parts), which passes backward into the bladder, and should be evacuated at once by the patient. Or a retrojection may be applied with an instrument the knob-like tip of which closes the urethra while the fluid is directed backward towards the meatus, thus washing out the discharge down the urethra. The regular passage of the sound should never be omitted in these cases, both for its immediate effect and to prevent the possible formation of a stricture.

Tuberculosis.—Tuberculous infection of the prostate is probably more common and more easily recognized than that of any other part of the genito-urinary tract except the testicle. The lesions consist in the development of tuberculous nodules in the gland, which go on to caseation or to the development of abscesses, although in rare cases spontaneous recovery

may take place under favorable conditions. If the disease is not near the urethra, it may run an absolutely latent course, giving no symptoms until it is very far advanced or until the testicle or the bladder is involved. If the lesions are near the urethra, it will begin with symptoms like those of an ordinary catarrhal prostatitis, but, as a rule, with less hyperæsthesia. There may be threads of mucus and tubercle bacilli in the urine. Micturition may be impeded by the swelling, especially if an abscess forms. Rectal examination reveals a slightly enlarged prostate with small hard nodules scattered through it, but the outlines of the gland may be rendered indistinct by an accompanying periprostatitis. The seminal vesicles will also be found to be thickened and nodular in many cases. When the deposits break down the prostate feels soft, and it may be entirely converted into a sac of pus. Pus may also form around the gland and make its way outward through the triangular ligament to the perineum, into the urethra, or into the rectum. Sinuses remain when the pus has been discharged.

Treatment.—When pus has formed it must be evacuated by incision; the remains of the prostate should be removed with a sharp curette if possible. The prostate may be exposed by a horseshoe-shaped incision, the anterior curve crossing the median line just behind the bulb of the urethra, and the ends running down on the sides of the sphincter ani so that that muscle will be raised in the flap. As the incision is deepened, the bulb of the urethra is drawn forward and the flap dissected backward until the capsule of the prostate is reached. The capsule may be incised and the disorganized gland removed by the curette and the finger. The urethra is often found dissected out, the remainder of the prostate having broken down into pus, and urine is discharged through the wound at once, or after a short interval, but the urinary fistula generally closes as the cavity contracts. The wound should be packed, and if the urethra is opened a catheter is introduced and left in the bladder for two or three days.

Abscess of the Prostate.—Suppurative inflammation of the prostate may occur in the shape of small follicular abscesses or extensive cavities in the substance of the gland, or the inflammation may extend beyond the capsule and produce an abscess outside the gland. These abscesses may have an acute course when they are due to pyogenic infection resulting from stricture, severe cystitis, or infection by unclean instruments. On the other hand, they may be slow and chronic when they occur in the course of tubercular disease. In the acute form there will be intense pain and a feeling of weight and throbbing in the perineum, perhaps associated with vesical and rectal tenesmus, and even with retention of urine. There may be a chill, and the patient may become profoundly septic. The abscesses most frequently burst into the urethra, but often make their way into the perineum, and may also discharge into the rectum. The gland, examined per rectum, will be found distended and very tender, and in the later stages a fluctuating swelling will be present.

Treatment.—Hot applications to the perineum and hypogastrium and hot rectal injections afford the best method of treatment in the early stages, but as soon as the presence of pus is probable an incision should be made. The pus may be reached by an incision in the perineum in the middle

line, carried inward until the urethra is exposed, and then the point of a narrow-bladed knife should be thrust directly upward between the rectum and the urethra, under the guidance of the finger in the rectum, until the pus is reached. The opening is enlarged by dilating it with forceps, and the cavity is irrigated and drained. This method is not very difficult, but it is much safer to expose the capsule of the prostate by the horseshoe-shaped flap described above and then open the abscess under the guidance of the eye. If properly treated, these cases usually recover without evil consequences, but fistulæ are apt to follow if they are neglected, and if they open spontaneously into the rectum burrowing and sepsis will take place from additional infection of the abscess.

Tumors.—**Hypertrophy** of the prostate, which is the most common form of tumor of that organ, is a fibromyo-adenoma, but it has already been considered in connection with the diseases of the bladder on account of its intimate relation to urinary diseases and the slight effect which it has upon the sexual function. Other neoplasms are found in the prostate, such as **lipoma**, but they are very rare, and only the malignant tumors require description. **Sarcoma** is found at all ages, and several cases have been observed in infancy. **Carcinoma** is more frequent in advanced adult life, but has also been noted at a very early age. In both varieties of tumor no symptoms are evident until the mass has attained a considerable size and interferes with urination or ulcerates on the vesical or urethral surface and produces hæmaturia and cystitis. At this stage rectal examination will reveal the prostate enlarged, stony hard to the touch, with indistinct outlines, and firmly fixed by the infiltration of the surrounding parts. Occasionally the gland is soft instead of hard. Operation is out of the question, and palliative measures, similar to those for advanced cancer of the base of the bladder, afford the only possible treatment. The disease is fortunately not common.

THE SEMINAL VESICLES.

The seminal vesicles are generally associated with the prostate in its **inflammations**, any form of prostatitis being liable to be accompanied by swelling of the seminal vesicles from retention or inflammation. In catarrhal prostatitis the condition of the seminal vesicles should always be ascertained by careful rectal examination, for the ejaculatory ducts are often obstructed and the vesicles suffer from overdistention. In such cases relief can be obtained by regular evacuation or *stripping* of the vesicles, which is executed by the pressure of the finger, or of a blunt, rounded instrument shaped somewhat like the curved finger, which is passed into the rectum above the organ and made to press forward upon each vesicle in turn so as to empty its contents. **Tuberculosis** invades the seminal vesicles from the prostate or the testicle. It should be treated similarly to tuberculosis of the prostate, and the organs can be reached by the perineal incision already described for that gland. The seminal vesicles have been successfully removed through a similar incision in cases of castration for tuberculosis when the vesicles were secondarily diseased but the prostate was healthy. When the prostate is exposed the rectum is separated from it, and the finger can

enucleate the seminal vesicles, a large steel sound being passed into the bladder to aid in protecting that organ. The result of these operations is still uncertain. Tumors of the seminal vesicles are so rare as not to require description.

COWPER'S GLANDS.

Inflammation.—Cowper's glands are sometimes, although seldom, subject to inflammation as a consequence of acute gonorrhœa. The development of this complication can be recognized by deep-seated lateral pain and tenderness in the perineum, sometimes associated with retention of urine. Examination by the rectum will serve to exclude acute prostatitis, and also ischio-rectal abscess, which would lie nearer the anus. **Treatment.**—Cold applications should be made to the perineum, laxatives given, and the patient confined to bed in hopes that the inflammation may be dissipated. If suppuration takes place, as shown by the occurrence of chills or an irregular hectic curve in the temperature, an incision should be made as early as possible. The abscesses are not so deep as those of the prostate, and the incision should be a lateral one just external to the bulb of the urethra. **Tumors** also develop in Cowper's glands, but they are of great rarity. They can be distinguished from tumors of the urethra by the symptoms, which are referred rather to the region of the rectum than to the urethra, rectal tenesmus or pain in defecation being present, while there is no retention of urine until the tumor reaches a large size, because its development takes place mainly towards the rectum. The diagnosis will seldom be made early enough to allow of successful treatment, as the tumors are usually malignant.

IMPOTENCE, STERILITY, AND FUNCTIONAL DISEASES.

By **impotence** is meant the inability to indulge in coition, which may be the result of congenital or acquired defects in the organs of generation, such as absence of the penis or testicles, or of loss of the power of erection. The latter may be due to imperfect circulation in the penis owing to an enlarged dorsal vein or damage to the erectile tissues, or it may be of nervous origin from exhaustion of the lumbar centres or weakness of the entire system. It may also be the result of certain mental states, such as fright, disgust, or mere self-consciousness.

Treatment.—Certain of these conditions do not admit of remedy, while others may be treated successfully by removal of their cause. A strong mental impression will often overcome impotence if it is due to psychical causes, although some of these cases are the most difficult to cure. The use of electricity, either galvanic or faradic, applied from the lumbar region obliquely down to the pubic bone and in the perineum, or with one electrode in the rectum and the other at the peno-scrotal junction, has a definite value, although its effect is probably mainly a psychical one. In any case where there is a psychical element, as well as in cases of sexual neurasthenia or exhaustion, and of incomplete development, it is wise to prohibit all attempts at sexual intercourse during the course of treatment, or to allow them only at long intervals when there seems considerable hope of their

successful accomplishment, as every failure increases the mental depression of the patient.

Sterility in the male is the result of a failure to fertilize the ovum, but it is by no means always associated with impotence, for although impotence is one cause of sterility, the latter may also result from any condition which impairs the vitality of the spermatozoa, excludes them from the seminal fluid, or prevents the proper ejaculation of the latter. In addition to impotence, therefore, sterility may be due to functional disturbances of the testicle, causing imperfect production of spermatozoa, to a chronic epididymitis, which prevents the spermatozoa from entering the seminal fluid, to a tight urethral stricture, which prevents ejaculation of the semen during the act of coition, or to any deformity, such as hypospadias, which hinders the deposit of semen in the vagina. Obstruction of the ejaculatory ducts due to inflammation or to tumors of the prostate has a similar effect. In some cases it has been found that spermatozoa were present in the seminal fluid but were not vigorous, and in others the fluid has been found entirely destitute of these organisms. Gonorrhœa and its sequelæ are the most frequent causes of sterility. The **treatment** of sterility consists in the removal of the cause, such as congenital deformity, urethral stricture, or chronic inflammation of the epididymis or prostate, or the cure of the impotence which is at the foundation of the trouble in some cases.

Masturbation.—The habit of masturbation or self-abuse produces many evil effects because of the over-indulgence in the sexual act, and especially because it is usually practised at an early age, when such excess is particularly injurious. It also has disastrous consequences on the moral nature of the individual. But its local effects upon the organs of generation, even when practised to excess, are not very serious. Its most frequent evil results are sexual and general neurasthenia and hyperæsthesia, a catarrhal prostatitis, and sometimes the production of local irritation and hyperæsthesia of certain parts of the urethra. Masturbation is sometimes only a symptom of stone in the bladder or of a narrow meatus or foreskin, and can often be overcome by removing such causes. In some cases the habit can be broken by friendly advice, or in very young children by restraint. In older persons the regular passage of a large cold urethral sound will often quiet the sexual hyperæsthesia, and lead to a cure if the individual is making an earnest effort to stop the habit. Many of the measures of treatment described in the next section will be found useful adjuvants. Masturbation is much less common in the female, and its effects are less serious. It may be due to similar causes, or to irritation of the vulva by adhesions, retained secretions, or parasitic worms from the rectum. The treatment is the same.

Spermatorrhœa.—Spermatorrhœa is a name given to the discharge of a mucous fluid from the genitals, which rarely contains spermatozoa, being generally the secretion of the prostate or of the deep urethra under sexual excitement. It is a symptom of slight catarrh or mere hyperæmia of the prostate, of very little importance, which is often exaggerated by neurasthenic individuals who are sexually irritable. If the seminal vesicles are distended, the discharge of their contents during defecation when

hard masses press upon them would be a very natural consequence, and of no pathological significance, even if the discharge contained true semen. The ordinary discharge under these circumstances is merely that of the prostate. In such cases the presence of disease of the seminal vesicles and of the prostate should be excluded by a careful rectal examination, and if any catarrhal condition be found, it may be remedied in the usual manner. Nocturnal emissions are also perfectly natural modes of expelling the surplus semen, and should not be considered symptoms of a diseased condition unless they occur too frequently for the strength of the individual concerned. Some strong and healthy men with very active genital organs may have very frequent seminal emissions, and for them this is not pathological, while for a neurasthenic individual such a discharge once a fortnight may be too much. Their importance to the individual can be estimated by the effect they have upon his strength, as shown by the symptoms of lassitude, nervous exhaustion, or irritability and lumbar pain, during the following day. Too frequent emissions can be avoided by strict abstinence from any thoughts of a sexual nature, by a plain light diet, regulation of the bowels, out-of-door exercise, a cool bedroom, and light bedclothes. Nothing should be eaten or drunk some hours before bedtime, and the patient should sleep on his side—a towel tied around the body with a hard knot in the lumbar region being useful to prevent rolling over on the back. Erections are frequently due to a full bladder, and the patient should cultivate the habit of waking once during the night to evacuate it. In bad cases a regular course of athletic physical training should be instituted, as it is well known that this not only improves the general health but lessens sexual hyperæsthesia. Above all things sexual intercourse is to be avoided until a cure is obtained, for nothing is more likely to increase the sexual hyperæsthesia, especially if it be practised in an irregular manner.

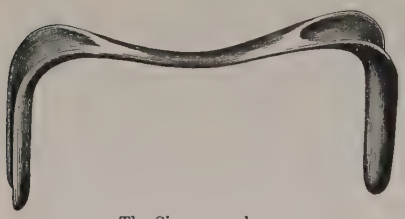
CHAPTER XXXVIII.

SURGERY OF THE FEMALE GENITALS.

METHODS OF EXAMINATION.

Inspection.—The external genitals, and, by the aid of the speculum, the vagina and cervix uteri also, are accessible to inspection. The best specula for general use are the Sims and the bivalve speculum. The Sims instrument (Fig. 864) is used in the left latero-prone position. (Fig. 865.) The patient should lie upon her left side, with the legs and thighs flexed, the upper thigh being flexed a little more than the lower, so that the heel of the right foot shall rest upon the ankle of the left. The table should be flat and elevated a little at the foot. The patient lies with the under arm behind her, and with the upper shoulder turned forward and depressed as much as possible towards the table, so that the thorax is partially rotated in that direction. In this position all strain is taken off the diaphragm and the abdominal muscles, and the abdomen and its contents tend to fall

Fig. 864.



The Sims speculum.

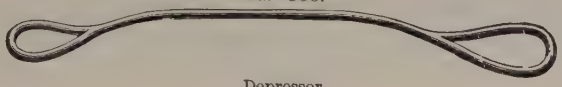
Fig. 865.

The left latero-prone or the Sims position. (Potter.)

towards the table. When the speculum is inserted, air enters and distends the vagina, and very slight pressure with an instrument called a depressor

(Fig. 866) on the anterior wall allows free inspection of the parts. The speculum should be held as shown in Fig. 867, the nurse's free hand draw-

Fig. 866.



Depressor.

ing the upper buttock and labium out of the way. The bivalve speculum (Fig. 868) may be used in this position or with the patient on the back in

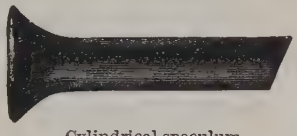
Fig. 867.

Method of holding the Sims speculum. (Baker.)

Fig. 868.

Bivalve speculum.

Fig. 869.



Cylindrical speculum.

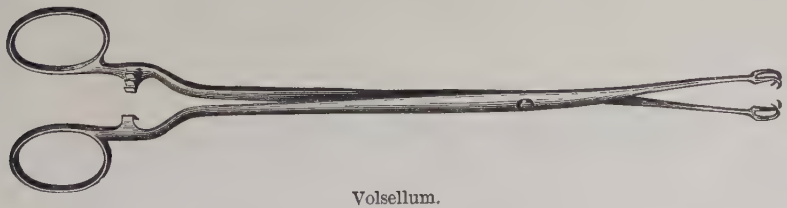
the lithotomy position, as may also the hollow cylindrical speculum. (Fig. 869.) Each of the latter has its uses, and they are more convenient than

Fig. 870.

Uterine tenaculum.

the Sims when no assistant is to be had. In some cases a tenaculum (Fig. 870) or a volsellum (Fig. 871) hooked into the anterior lip of the cervix will

Fig. 871.

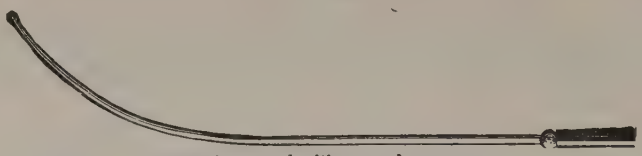


Volsellum.

bring it better into the field of view. The uterine probe or sound is made of soft metal, such as copper (nickel-plated), so that it can be bent into a

curve similar to that of the uterus. (Fig. 872.) It is employed to ascertain the patency, length, and direction of the uterine canal, and must be introduced with great gentleness, as it might perforate the wall of a diseased uterus. It should always be sterilized, lest an infectious endometritis or salpingitis follow its use, and for the same reason it should be passed with

Fig. 872.

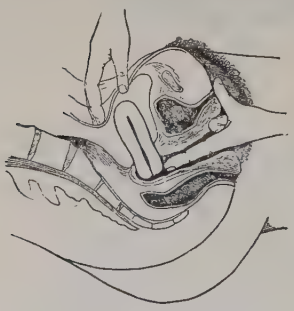


Uterine sound with normal curve.

the aid of a speculum, so as to avoid contamination by the vaginal secretions. When there is marked flexion the passage of the sound may be facilitated by drawing down the cervix with a tenaculum, or pushing up the fundus with the finger, so as to straighten the uterine canal.

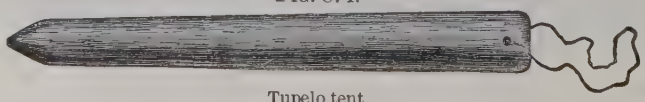
Digital examination teaches more than inspection. The best position for a thorough pelvic examination is with the patient lying on her back on a table with the knees drawn up. In some cases general anæsthesia is necessary for satisfactory palpation. The examining finger should be well lubricated. The index finger is then introduced into the vagina while the fingers of the other hand press upon the abdominal wall just above the pubes, and between the two all the pelvic organs may be distinctly palpated. (Fig. 873.) When the hymen is intact a rectal examination will often supply all necessary information. In women who have borne children a little higher reach can be obtained by introducing two fingers into the vagina, and a still more thorough examination may be made by introducing the middle finger into the rectum while the index finger is in the vagina, the perineum being pressed far upward. The condition of the cervix, the position and size of the uterus, the ovaries, and the tubes are carefully studied. By drawing down the uterus with a volsellum fixed in the cervix the posterior and anterior walls can often be examined up to the fundus by the finger passed into the rectum or the bladder. The uterine canal may also be dilated so as to admit the finger for examination. This may be done by tents, the tissues being rendered very soft and pliable by their action. Tents are made of tupelo

Fig. 873.



Bimanual palpation. (Mundé.)

Fig. 874.



Tupelo tent.

(Fig. 874) or laminaria or sponge, and expand under the influence of the heat and moisture of the body. They are, however, difficult to use in an

aseptic manner, and it is safer to employ instrumental dilatation by passing a series of sound-like instruments, or by dilating forceps, the blades of which are separated by compressing the handle by the hand or a screw. Of the latter the Goodell-Ellinger instrument (Fig. 875) is the best.

In making the diagnosis of pelvic tumors the possibility of **pregnancy** is always to be borne in mind, the most useful signs of that condition being

Fig. 875.

Goodell-Ellinger uterine dilator.

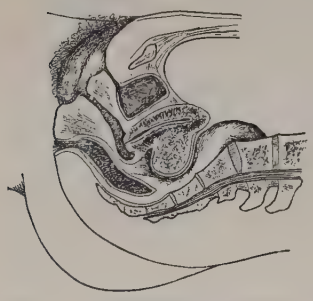
the enlargement of the uterus, the softening of the uterine wall at the level of the internal os in the early stages, the patulous cervix later, the rhythmic contractions of the organ, the fœtal movements and heart-sounds, ballottement of the fœtus, and the changes in the mammæ. Palpation may reveal the ovaries and tubes on the sides and the round ligaments passing to the summit of the tumor. If there is any suspicion of pregnancy, the sound should not be passed into the uterus, except in urgent cases, as miscarriage will follow. Errors are most likely to occur in cases of hydramnios.

If a mass is felt in the pelvis, its attachment to the uterus is ascertained by moving the tumor with the hand outside, the finger in the vagina observing if the cervix moves in a corresponding way. If the fundus cannot be felt separate from the tumor, a sound introduced into the uterine canal will determine the direction of the fundus and whether the mass uniformly surrounds it or lies upon one side. If the mass is upon one side and distinct from the uterus, it may be an **inflammatory mass** formed by the tubes and ovaries, a **distended tube**, or a **tumor of the ovary**. In the first case there will be a history of an inflammatory trouble, such as pain and uterine discharge, the mass will be uneven on the surface, fixed in the pelvis, and very commonly a similar condition will be found on the other side. A distended tube may contain blood, serum, or pus; it may or may not be tender to pressure, and if it contains pus it will usually be fixed by adhesions. A tumor of the ovary will be globular in shape; it is generally movable, and the uterus will not move with it. The pedicle can often be felt attached to one horn of the uterus. A *cyst* developing in the *broad ligament*, whether parovarian or ovarian, growing downward in the pelvis, will tend to displace the uterus towards the other side and more or less fix it in its position. A **fibroid of the uterus** developing upon one side, even if it has a narrow pedicle, will promptly move the uterus with it. Intraperitoneal

fibroids are usually movable, although the extraperitoneal tumors may be fixed by folds of the broad ligament. An extraperitoneal **hæmatocele** will form a rather doughy tumor, surrounding the uterus so as to fix it completely, usually being more marked on one side of the pelvis than on the other. An intraperitoneal hæmatocele will be bilateral, will fill Douglas's cul-de-sac, and may extend high enough to be felt by the hand on the abdomen. The tumor will give one the impression of something poured into the pelvis and solidified there, rather than of a distinct mass. Similar masses, however, are produced by the exudate of local peritonitis. When a tumor lies in Douglas's cul-de-sac the fingers can often be passed between it and the uterus, but when the mass has developed in the broad ligament and extended behind the uterus by detaching the peritoneum, this will be impossible.

Displacements of the uterus are readily recognized, as a rule, by this examination, and the position of the fundus located; but if there is any doubt, as is often the case when a tumor of about the same size lies close to the uterus (Fig. 876), the passage of the uterine probe will point out the position of the fundus. The mobility of the uterus must be carefully studied in each case, and if it is fixed the fixation may be due to adhesions, the result of recent or former inflammation, or to the presence of a tumor or of blood-clot. When **malignant disease** attacks the uterus that organ is usually enlarged, and in the latter stages becomes fixed in the pelvis by the spread of the disease through the cellular tissue about the organ. Tumors of the uterus and ovary will be considered later. **Tumors of the vagina** are readily felt by the finger, and it can be ascertained whether they grow from the vaginal wall or from the cervix, or protrude through the cervical canal into the vagina as a polypoid growth. When **abscesses** form in the neighborhood of the vagina, fluctuation can sometimes be made out distinctly with the finger. In **floating kidney** or **spleen** the organ may fall into Douglas's cul-de-sac, but can usually be returned to its place and its true nature recognized.

FIG. 876.



Tumor on posterior wall of uterus. (Mundé.)

MENSTRUAL DISTURBANCES.

In the symptomatology of the diseases of the female genitals disturbances of the menstrual function are very common. Absence of the menses, or **amenorrhœa,** may be due to malformation of the organs, but is most frequently the result of anæmia, especially in tuberculosis. In the latter case it is to be considered as a conservative symptom, and attention should be directed to the general condition, without making any attempt to bring on the interrupted function, which will be re-established if the patient's health is sufficiently restored to provide the necessary blood. **Dysmenorrhœa,** or painful menstruation, may be due to mechanical causes, such as an obstruction in the uterine canal by stricture, an abnormally small os, acute flexion, or merely the swelling of inflammation. In such cases the pain is usually

most intense at the beginning of menstruation, is colicky in character, and may be extremely severe, being relieved only by very large doses of morphine, but it generally subsides as the function becomes established. In other cases, however, the pain is throbbing, with a feeling of fulness in the pelvis and aching in the back and loins, which may be felt only at the beginning of menstruation or may persist throughout. Such symptoms are common in cases of malposition of the uterus without acute obstruction or inflammation, being due to the venous congestion and the dragging of the heavy organ. Obstructive and congestive dysmenorrhœa must be treated by removing the cause. Dysmenorrhœa of neuralgic or ovarian origin belongs to medicine rather than to surgery.

Menorrhagia is a too profuse menstruation, and **metrorrhagia** is a flow occurring between the regular periods. The former is a symptom of fibroids, of endometritis, especially of the fungoid form, and of malposition of the uterus accompanied by venous congestion. Metrorrhagia usually indicates the presence of a fibromyoma, especially one within the cavity of the uterus. It may be a symptom of malignant disease in the first stages. Whatever cause is found for these conditions must be removed, and when the flow itself demands treatment, in mild cases the administration of gallic acid and cinnamon water or ergot will answer, but in severe cases packing of the uterus and vagina or curetting the uterus must be resorted to.

CONGENITAL DEFORMITIES.

Complete absence of the genitals is rarely found, but **absence of the vagina** is not uncommon. In such cases the vulva is usually well formed, but no opening exists between the labia minora except the meatus. Occasionally only part of the vagina is absent, either the upper or the lower part being naturally formed. The uterus may be absent, and if no uterus can be found on rectal examination, no attempt should be made to rectify the deformity. If, however, a uterus of fair size is found, an artificial vagina can be made by blunt dissection in the vesico-rectal space, between the urethra and the rectum, up to the uterus. This can be kept open by dilatation with glass plugs, or by the transplantation of a flap of skin from the vulva or from the thighs into the wound, suturing it to the cervix if possible. If no uterus is present or the organ is undeveloped, it will be difficult or impossible to keep the new canal patent. In some cases of absence of the vagina, sexual intercourse takes place through the dilated urethra, and if the uterus is present the cervical canal sometimes connects with the bladder, and menstrual blood may escape through that organ. No operation should be undertaken before puberty. If the condition is hopeless, the removal of the ovaries, which are usually fairly well developed, will often prevent unpleasant nervous symptoms. Women with these congenital deficiencies are not infrequently of fine physique, and possess feminine characteristics.

Reduplication of the genital organs is not uncommon. There may be a septum dividing the vagina entirely or in part, or extending up through the cavity of the uterus. The latter is sometimes divided by a septum when the vagina is normal, and in other cases the entire fundus of the uterus is double, with two cavities, resembling the uterus bicornis of the lower animals,

the cervix being single. Very rarely a double uterus is found with two separate vaginæ. Reduplication of the ovaries and tubes is one of the rarest of these deformities. The condition usually needs no treatment, except that division of the vaginal septum may be necessary to facilitate sexual intercourse or parturition. True **hermaphroditism** is a rare deformity, the great majority of these cases being, as already mentioned, instances of hypospadias in the male. A supernumerary ovary is a very rare occurrence. Among the congenital anomalies should be mentioned **atresia** or **stricture of the cervix**, and **hypertrophic elongation** of that organ. Atresia occasions the same menstrual retention as an imperforate vagina or hymen, and requires incision for its relief. Stenosis of the cervical canal is apt to be a cause of endometritis and its more serious complications if infection occurs, as it prevents free drainage of the secretions. It should be treated by dilatation, aided, if necessary, by superficial incisions of the wall of the canal. The dilatation may be accomplished by repeated introductions of dilating sounds, or may be made in one sitting by means of the Goodell-Ellinger dilator. The same treatment is indicated in cases of obstruction due to sharp congenital flexions, and a stem pessary should be worn afterwards. An elongated cervix may prevent conception. It may even project beyond the vulva, and should be treated by amputation of the redundant part, the canal being slit open to insure an os of sufficient size.

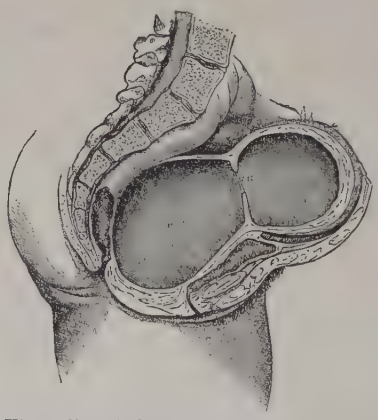
Adherent Labia.—The labia are often adherent in the infant, simulating atresia of the vulva, but can usually be separated by a blunt instrument like a director, although the use of the knife is occasionally necessary.

Atresia of the Hymen.—The most common malformation is atresia of the hymen. (Fig. 877.) The opening in the hymen should normally be of

Fig. 877.

Imperforate hymen. (Hirst.)

Fig. 878.



Uterus distended with blood from imperforate hymen. (Hirst.)

considerable size. In some cases it is very narrow, reduced to a pin-head, or even absent. When the hymen is imperforate and menstruation begins at puberty, the discharge collects behind it, distends the vagina, carries the uterus up, and even distends that organ, producing large tumors which reach half-way to the umbilicus (hæmatometra). (Fig. 878.) The symptoms

of this condition are absence of the menses, occasional attacks of cramp-like pains especially at the menstrual epoch, signs of pressure by the large tumor (such as constipation and frequent micturition), and the protrusion at the vulva of the distended hymen. The contents of these tumors are blood in a more or less clotted condition. If left unrelieved, infection is certain to take place sooner or later, and fatal sepsis usually results. The treatment consists in freely incising the hymen, clearing out the clots completely, irrigating the large cavity with sterilized water, and packing the vagina with sterilized gauze, the irrigation and packing to be renewed if the temperature rises. The principal danger in the operation is the risk of infection, and every precaution to maintain asepsis must be taken.

INJURIES OF THE FEMALE GENITALS.

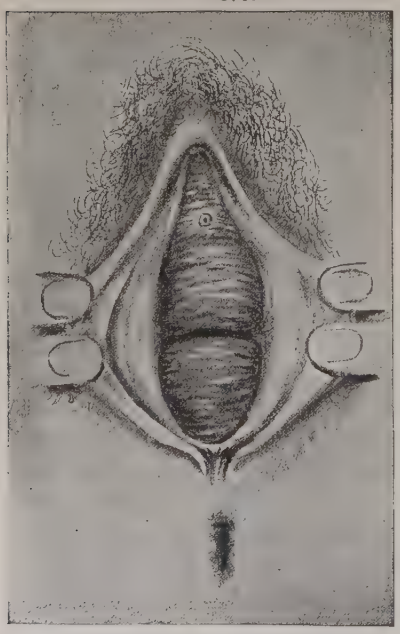
The female genitals are but little exposed to injury, but falls upon the buttocks may produce contusions of the vulva, an immense hæmatoma often forming in the labia. Falls upon sharp objects may produce lacerated wounds of the parts, or a stake may even enter the vagina and open the peritoneal cavity or wound the rectum or bladder. Gunshot wounds are occasionally, but rarely, met with. The pregnant uterus may be injured by penetrating wounds of the abdomen, and has most frequently been wounded in the accident of goring by cattle. Wounds of the uterus are most frequently the result of attempts at abortion, but may follow incautious use of the uterine sound. The most common injury, however, is the **rupture of the uterus** during labor. The rent usually begins in the lower third, where the tissues are stretched over the presenting part of the child, but may extend upward to the fundus. The laceration may be incomplete, either the mucous membrane or the peritoneum remaining intact. It may also be entirely extraperitoneal, but more frequently it opens the peritoneal cavity. The diagnosis of complete rupture is easy: the child recedes, and may escape into the peritoneal cavity, with signs of great shock and cessation of the labor-pains. In the incomplete form there will be an arrest of the descent of the presenting part of the child, or even recession, unusual hemorrhage, loss of the symmetrical shape of the uterus, and thinning of its lower segment, as felt through the abdomen. The **treatment** of the accident consists in immediate laparotomy, with removal of the child and placenta, and hysterectomy should generally follow. If the mother were in good condition, suture of the rent would be preferable, but, as a rule, she is moribund, and her only hope is the rapid completion of the operation, which is best obtained by transfixing the cervix with pins, surrounding it with a ligature, and cutting away the uterus. The pedicle is secured in the abdominal wound. A drain should be inserted in Douglas's cul-de-sac and also in the abdominal wound. The abdomen should be thoroughly washed out and the wound closed. Recovery is rare, for, even if the patient survives the shock, peritonitis is very apt to follow.

Injuries to the vagina in coitus occasionally occur from a disproportion of the parts or from too violent efforts in intoxication. The penis has been forced through the recto-vaginal septum or into Douglas's cul-de-sac. All these injuries are apt to be followed by profuse hemorrhage, on ac-

count of the great vascularity of the parts, but their principal danger is the injury to the neighboring organs or subsequent infection. Infection in this region may produce extensive suppuration within the pelvis or result in peritonitis. Self-inflicted injuries to the parts are occasionally seen in demented persons. The **treatment** of these injuries consists in the arrest of hemorrhage by ligature or by packing the vagina, after thorough cleansing and removal of torn and gangrenous tissues. Extensive wounds may be sutured, but this will seldom be necessary. Thorough asepsis and drainage must be provided, and a beginning cellulitis or an infected hæmatoma treated by early incision. **Foreign bodies** are found in the genitals, sometimes introduced accidentally, but more frequently with intention. If allowed to remain long in place, as is sometimes the case with neglected pessaries, they may become incrusted with lime salts and produce deep ulcers. When an obstinate vaginitis exists in children a careful search should always be made for a foreign body.

Laceration of the Perineum and Cervix.—As the result of parturition, tears are often found in the vagina and perineum, either lateral or directly backward. The perineal laceration may be slight, involving only the vaginal mucous membrane and the commissure, it may divide all the tissues down to the sphincter ani, or it may be complete and extend into the rectum. The principal factor in these injuries is not the laceration of the skin and mucous membrane, but the damage to the pelvic fascia which enters into the structure of the perineum. The loss of the support below thus produced leads to eversion of the vaginal mucous membrane, especially on the posterior wall. This eversion is aided by the falling forward of the lower part of the rectum, and the pouching of the latter produces an obstruction to defecation and is constantly increased by the straining during that act. As the posterior vaginal wall descends it drags the cervix of the uterus forward and downward, and that organ takes the first step towards retroversion and prolapse. The bladder also prolapses quite frequently. The prolapsed vaginal wall is called a rectocele or a cystocele (Fig. 879), according to the organ affected. In some cases the extent of the laceration is not evident until the fingers are passed into the vagina and pressure made towards the rectum, when it will be discovered that the entire fascial support of the perineum has been torn away, leaving it lax and non-resistant, although the vulvo-vaginal opening may not appear much larger than normal. The sphincter ani has been divided by these subcutaneous lacerations.

Fig. 879.



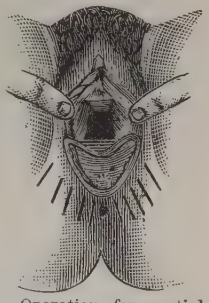
Cystocele and rectocele. (Mundé.)

If this muscle is weakened or destroyed, the woman's condition is pitiable from the loss of control over the fecal movements, or at least over flatus.

Treatment.—The injury should be repaired as soon as received, unless the sphincter ani is involved, a few stitches being placed so as to bring the raw surfaces together. Innumerable plastic operations have been devised for remedying this condition secondarily, but we can mention only a few. In all cases the hair should be cut close or shaved and the vagina thoroughly washed with soap and water before the operation. The patient should be in the lithotomy position.

A. Operations for Partial Laceration.—1. In the simplest method the cicatricial skin and mucous membrane are pared from a triangular surface on each side of the vulva, the two being continuous in the middle line behind. (Fig. 880.) The freshening can usually be limited to the part about the hymen, and the normal skin should never be encroached upon. If a rectocele is present, the freshening must extend up to its crest. A deep suture is then passed, the needle entering the skin one-quarter of an inch away from the edge of the wound at its anterior angle, traversing the lateral tissues very deeply to pick up the torn fascia, and being carried backward and inward towards the median angle of the wound. It passes beneath the latter and returns in a similar course on the other side. Other sutures are passed parallel to this first one, about one-quarter of an inch apart. In passing these sutures one finger of the left hand should be kept in the rectum, in order to avoid perforation of its mucous membrane, as the needle must sometimes pass very close to it in order to pick up the submucous rectal tissues. The sutures should not be drawn too tight, for fear of strangulation, as œdema is the rule after these operations.

Fig. 880.



Operation for partial laceration of the perineum, surfaces freshened, and sutures placed ready for tying. (Goodell.)

2. A second form of operation, suggested by Emmet, makes a butterfly or clover-leaf denudation of the part, one part of the trefoil being on each side of the perineum, and the central one being formed on the prolapsing posterior vaginal wall. The sutures are passed in this operation so as to draw the three leaf-shaped denudations into a bunch, the two sides of the vulva being brought together and the rectocele drawn down against them so as to form a solid mass. This operation may be performed internally, as suggested by Emmet, by limiting the denudation to the membranes within the introitus.

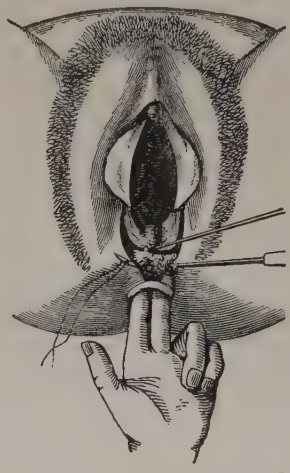
3. The perineum may be repaired by a split-flap method, similar to that suggested by Jenks and Tait. The parts are put upon the stretch by two fingers in the anus, and tenacula hooked in each side of the labia, so as to pull the edge of the perineum out in a horizontal line. A sharp-pointed pair of scissors is introduced at the posterior edge of the vaginal mucous membrane and horizontal cuts made, so as to split the septum into two flaps. (Fig. 881.) In deep lacerations the tissues of the vaginal flap are very thin, and consist of the vaginal mucous membrane only. This splitting of the perineum is carried to the depth of an inch or an inch and a half and well out on the sides, arching slightly forward at each end. The middle point of the vagi-

nal flap is then picked up with toothed forceps or a tenaculum and drawn directly forward, while a similar instrument pulls the centre of the rectal flap directly backward, converting the transverse diamond-shaped opening to a median diamond. Sutures are then introduced transversely (Fig. 882),

Fig. 881.

Incision for split-flap method. (Madden.)

Fig. 882.

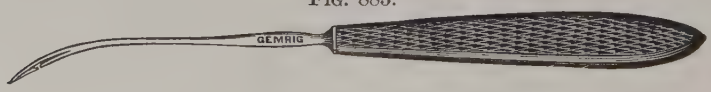


Split-flap method; first suture. (Madden.)

the first suture being placed in the middle of the wound at the angles of the former horizontal incision. Working backward from this point, parallel stitches are passed until the posterior angle is closed. A few silk sutures are passed anteriorly, bunching up the vaginal flap, and the originally horizontal incision is converted into a vertical one.

Sutures.—Either silk, silkworm-gut, or catgut may be employed for sutures. Silver wire is not much used now. The needles may be straight, but a curved Hagedorn is much easier to use, and a needle on a handle (Fig. 883) may be employed with advantage by the novice. In all these

Fig. 883.



Needle on a handle. (Peaslee needle.)

operations a continuous buried suture may be introduced. The wound is spread widely open, a curved needle threaded with fine chromicized catgut is introduced at the bottom of the wound, picking up a little of the raw surface on each side, and the thread is tied. A continuous suture is then passed, running along the deepest part of the wound, picking up only a little tissue on each side. Having made this first tier, a second tier is introduced, and so on in successive steps until the entire wound is closed. It is well to interrupt the suture by a knot at intervals. The edges of the mucous membrane may be united by buried sutures also, or ordinary stitches can be employed. When this buried suture is employed in cases in which there has been much lateral injury of the fascia, it is wise to add

a couple of deep external sutures to draw the torn edges of the latter together. The advantages of the buried suture are that there are no sutures to be removed, no stitch-holes to carry infection to deeper parts, and no spaces left where possible blood-clot can collect. The disadvantages are the possibility of strangulation if the sutures are drawn too tight, and the fact that if infection should take place the entire wound must be opened in order to relieve the suppurating point.

Fig. 884.

Stoltz's operation for cystocele, with circular suture inserted; with denudation for Hegar's operation for rectocele and lacerated perineum.

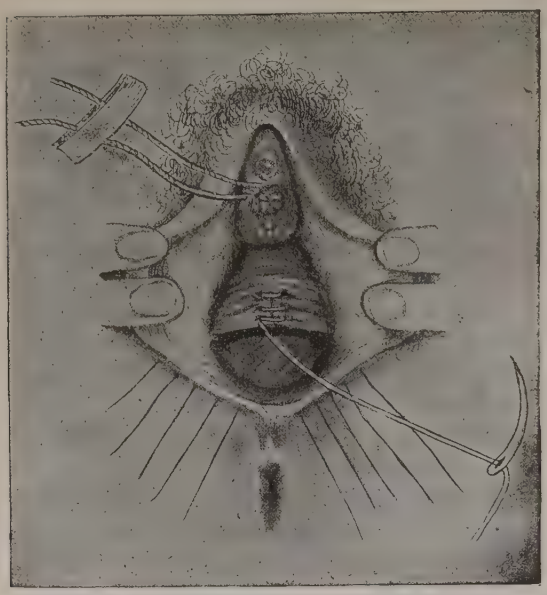
The **rectocele** is sufficiently closed in by the perineal operation, but if a marked **cystocele** is present it will require a separate denudation and suture. An oval space should be pared on the most prominent part of the prolapse, and its edges united in the median line in the long axis of the vagina by buried catgut or ordinary sutures. Or a circular denudation may be made (Fig. 884), as suggested by Stoltz, and then folded in by a purse-string suture passed around its edges. A continuous suture is made in the mucous membrane just beyond the denuded area, and when the two ends of the thread are drawn upon and the raw surface is pushed inward, the latter forms a pouch, and the cut edges of the mucous membrane are brought together across the neck of this pouch. (Fig. 885.) The vagina should finally be loosely packed with gauze.

In the after-treatment of these cases the urine should be drawn regularly by catheter, or, if this is considered unwise for any reason, the urine should be passed in the bed-pan while a stream of irrigating fluid from a fountain syringe is allowed to run over the vulva. If the urine is drawn, the gauze in the vagina can be left for several days, unless there is much uterine discharge, when a simple strip of gauze should be placed in the vagina daily for drainage. Vaginal irrigation will be unnecessary unless voluntary micturition is permitted. The patient should be kept in the recumbent position for at least two weeks, and preferably three, until union has become perfect. The bowel contents should be kept soft and moved every day.

B. Operations for Complete Laceration.—Complete lacerations of the perineum are those which extend through the rectal septum and the sphincter ani. In rare cases the sphincter ani or the greater portion of it will be found torn but the rectal mucous membrane left intact. In com-

plete lacerations we have two difficulties to deal with—the restoration of the muscular action of the sphincter ani and the avoidance of infection from the rectum. The split-flap method is the best for closing these lacerations. If the septum is torn high up, it is well to do the operation in two sittings, first closing the rent in the septum down to the sphincter. To unite the sphincter, the parts are put upon the stretch by sharp hooks, and with knife or scissors the septum between the rectum and the vagina is split into two layers for a depth of about half an inch, the incisions running laterally into the remains of the septum as far as they can be recognized. On the sides of the gap all traces of a septum may have disappeared, leaving a smooth surface passing from one labium majus around the posterior border of the anus to the opposite side. The divided sphincter lies like a transverse band along the posterior margin of the anus, and can often be felt as a soft, rounded border under the skin. The ends are usually marked by a dimple in the skin. If the muscle is stimulated by the sudden application of heat or cold, or by electricity, the fibres will be seen to contract and draw upon the skin at the ends. When these points have been located, the incision through the recto-vaginal septum is to be continued down on each side until the ends of the muscular fibres are freely exposed, and here the ends of the V-shaped incision terminate. A couple of heavy sutures are introduced an eighth of an inch away from the edge of the wound at this point, in order to pick up the ends of the torn muscle on each side, but are left untied. (Fig. 886, *ab.*) Interrupted sutures of fine silk are then applied to the two edges of the flap of rectal mucous membrane, beginning at the apex of the V, and these edges are united down to the muco-cutaneous juncture of the anus. Similar sutures are then applied on the vaginal surface, and after the wound has been closed the heavy sutures through the muscular fibres are tied (Fig. 886, *a'b'*), bringing the divided muscle together.

Fig. 885.



The same, with the cystocele suture tied and the rectocele stitches partly introduced.

Fig. 886.

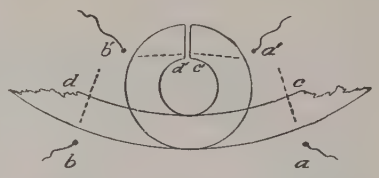
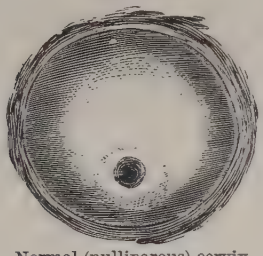


Diagram of suture of torn sphincter ani: *cd*, the sphincter; *ab*, suture in place, its course shown by dotted lines; *a'b'*, the suture when tightened, drawing *cd* into the ring *c'd'*.

The bowels are kept closed by small doses of opium for three or four days, constipation being aided by strict limitation of food, but a milk diet should be avoided because of its tendency to form hard masses of feces. Before the first movement of the bowels an injection of a large quantity of warm water should be given, and retained long enough to soften the feces as far as possible, or, if they are hard, an injection of ox-gall may be used, or the mass may be broken up by the little finger introduced into the anus. An ounce or more of olive oil is to be thrown into the rectum so as to lubricate the lower part just before the bowels move, and during their action it is well to have lateral pressure made by the fingers of the nurse, so as to prevent gaping, the forefinger and thumb being placed on each side of the labia majora. The patient must on no account be allowed to strain. If gas collects in the rectum and causes pain during the period of constipation, it may be withdrawn by the introduction of a catheter.

Laceration of the Cervix.—The cervix (Fig. 887) is always torn slightly in parturition, and often to such an extent as to produce a positive

Fig. 887.



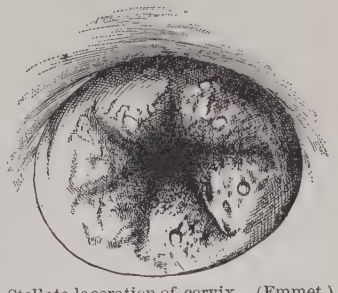
Normal (nulliparous) cervix uteri. (Madden.)

Fig. 888.

Unilateral laceration of cervix. (Emmet.)

deformity. The small lacerations require no attention, but severe tears may extend to the vaginal junction, and may involve the base of the bladder or the ureters and form urinary fistulæ. They may be single (Fig. 888) or multiple, a bilateral tear being especially common. They usually lie at the side, as if that were the weakest point, but may have a stellate arrangement when multiple. (Fig. 889.) As a result of the laceration the cervical mucous membrane is everted and becomes the seat of a chronic inflammation with cystic hypertrophy of the Nabothian glands. The wounds are generally infected from the first, and consequently heal with the production of much cicatricial tissue, which may extend into the surrounding cellular tissue. These masses of cicatricial tissue may compress the nerves and cause severe symptoms which may demand treatment by complete excision of the scar-tissue, even when the laceration itself is trifling. Subinvolution, endometritis, and salpingitis are frequent consequences of the infection of these wounds. The large and heavy uterus is often retroverted or prolapsed, especially when a

Fig. 889.



Stellate laceration of cervix. (Emmet.)

laceration of the perineum occurs at the same time, as is the rule. Malignant disease probably often results from the inflammation and chronic irritation of a lacerated cervix.

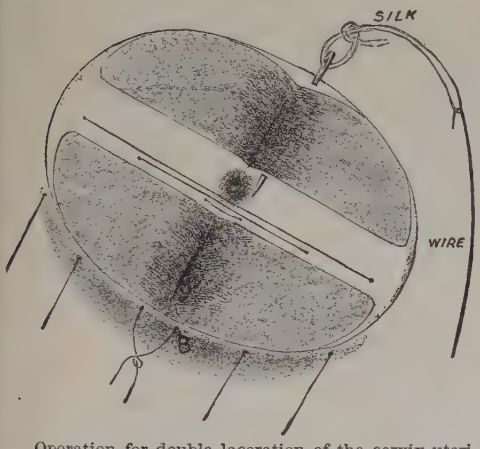
Symptoms.—The symptoms of a laceration of the cervix which has existed for some time are pain in the back and pelvis, leucorrhœa, menorrhagia, and other disturbances from the accompanying uterine displacement and inflammation. They are by no means proportional to the degree of the tear, as a small fissure may cause quite severe symptoms. All lacerations which extend to the vaginal junction or which cause eversion of the cervical mucous membrane demand operation, and also slight tears which cause severe symptoms. The diagnosis is sometimes easier to the touch than to the sight, superficial union having occurred across the tear, and it may be difficult to determine the situation of a unilateral laceration, as the uterus inclines towards the injured side. The patient should be examined with a Sims speculum, the uterus drawn down by a tenaculum, and the sound introduced, which will give the true direction of the uterine canal and render evident the extent and exact situation of the laceration.

Treatment.—It is well to repair these injuries by suture immediately after their occurrence, but the precise shape and relations of the cervix are not always evident at that time, and the exhaustion of the patient from shock or loss of blood, or some external circumstance, may make the operation impossible. Subinvolution, endometritis, and other inflammatory conditions are to be reduced as far as possible by rest, hot douches, and local applications before a plastic operation is undertaken.

The operation should be preceded by a thorough curetting of the uterine canal, which can be done at the same sitting unless the discharge from the endometritis is very purulent, in which case the curetting should be done several days beforehand. In many of these cases there is great hypertrophy of the vaginal portion of the uterus, and amputation is to be preferred to any plastic operation. The plastic operation is done by fixing the uterus with a tenaculum and drawing it well down, the patient being either in the dorsal or in the lateral position as preferred. The surfaces of the angular cleft in the cervix are freshened and all cicatricial tissue at the angle excised, preferably with the scissors, and the wound is closed by sutures of chromicized catgut, silkworm-gut, or silver wire. A straight, short, round needle, or a Hagedorn needle of suitable curve, may be used, and should be passed towards the cervical canal parallel with the angle of the wound (Fig. 890), and returned by a reverse course on the other side. If wire is used it is bent and hooked into a "carrying loop" of thread on the needle, but fine wire can be threaded directly into a Hagedorn needle. Two or three sutures are introduced parallel to the first. The sutures, when tied or twisted, draw the edges of the wound together, and convert it into a linear incision on the outer side of the vaginal portion. (Fig. 891.) The sutures must not be drawn so tight as to produce strangulation of the tissues. A bilateral laceration is treated in a similar manner, both sides being pared and all the sutures inserted before any are tied. It is seldom necessary to employ a ligature, as the introduction of the sutures usually controls the hemorrhage perfectly. If the cervix is very hypertrophic, a large amount of tissue may be cut away,

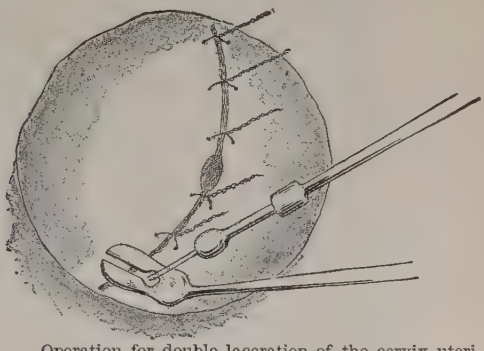
so as to result in a wedge-shaped partial excision of the cervix. If the cervical mucous membrane is greatly degenerated, containing many cysts of the Nabothian glands, it may also be extirpated in part, only a narrow strip being left to preserve the site of the uterine canal. In operating upon very deep fissures, injury to the ureters must be avoided, and the cellular spaces at the sides of the uterus should not be opened too freely. All aseptic precautions must be taken, and after the operation the vagina should be packed with gauze. In the majority of cases some plastic operation upon the perineum will be necessary at the same time. The after-treatment of these cases is similar to that of laceration of the perineum. The sutures should be removed at the end of a fortnight or three weeks.

Fig. 890.



Operation for double laceration of the cervix uteri, showing the denuded surfaces, the sutures placed ready for tying on one side, the needle passing on the other side, the wire suture, and the "carrying loop" of thread. (Mann.)

Fig. 891.



Operation for double laceration of the cervix uteri, showing the wound closed and the last wire suture being twisted. (Mann.)

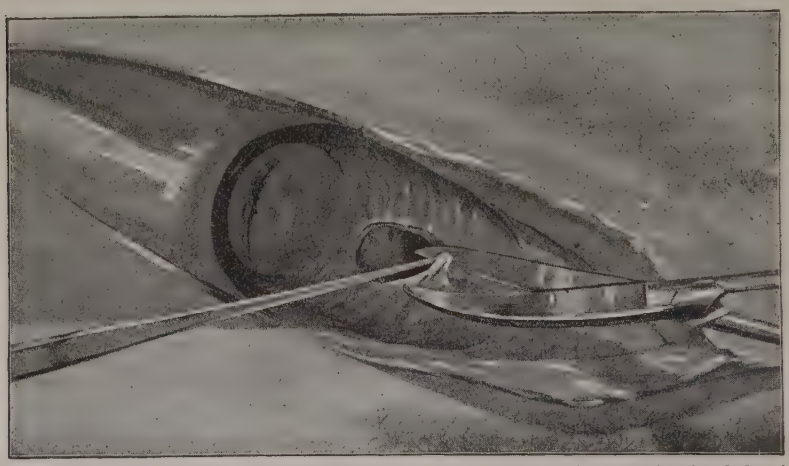
Vaginal Fistulæ.—Fistulæ between the vagina and the rectum, or between the vagina and the bladder, are very frequent as the result of difficult parturition. The openings may be so large that three or four fingers can be passed through, and the uterus may be implicated in them, especially if the opening extends up into the cervix as a consequence of laceration of that part. Small fistulæ often close spontaneously, especially those made for drainage of the bladder in cystitis. Plastic operations for the repair of these fistulæ are among the most difficult in surgery.

Treatment.—The methods which we have employed with the best success for both vesical and rectal fistulæ are the following: 1. The border of the fistula is freshened by cutting away the edges obliquely, paring off more from the vaginal side than from the other (Fig. 892), and sutures of silkworm-gut or of silver wire are then passed through in such a manner as to embrace the vaginal mucous membrane and the submucous tissue on the other side and to avoid entering the bladder or rectum. (Figs. 893 and 894.) The sutures must be placed very close together, not over an eighth of an inch apart. The stiffness of the gut or wire is an advantage, as it acts like a splint: we prefer the former, because it is easier to introduce. The needles

may be round and straight or Hagedorn curved needles, but the latter require some experience, as they are apt to make too large a puncture unless carefully handled.

2. The Split-Flap Method.—Instead of paring the borders of the fistula, a sharp knife is made to incise the border between the vaginal and the rectal or vesical mucous membrane to the depth of a quarter of an inch on all sides.

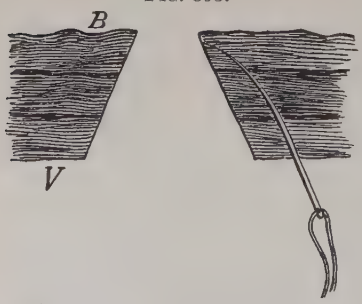
FIG. 892.



Operation for vesico-vaginal fistula. The Sims speculum in place, the cervix appearing just below it. The tenaculum and scissors are employed in paring the edges of the fistula. (Jewett and Polak.)

The vesical or rectal mucous membrane is then turned into the corresponding organ, and fine catgut or silk sutures are inserted on the raw surface of this flap and tied so as closely to approximate the edges. In passing these stitches the needle should be very small, and must not perforate the mucous membrane of the rectum or bladder, but should take up only the submucous tissues. The edges of the vaginal flap are then turned into the vagina and united by silkworm-gut or silver wire sutures passed in the ordinary way. The sutures in the first flap are thus buried and protected from infection, because they do not penetrate the mucous membrane on either side, while the stitches in the vaginal flap take the strain and remove all tension from the first. The line of union in either of these methods must be in the direction of the least tension, and it is a matter of indifference whether it lies parallel to the long axis of the vagina or crosses it transversely or obliquely. Tait uses a single submucous suture in operating upon small fistulæ by the split-flap method, passing it around the opening between the two flaps and puckering them up like a purse-string by tying it. We have also employed the Szymanowsky double-flap principle of turning a flap of vaginal

FIG. 893.

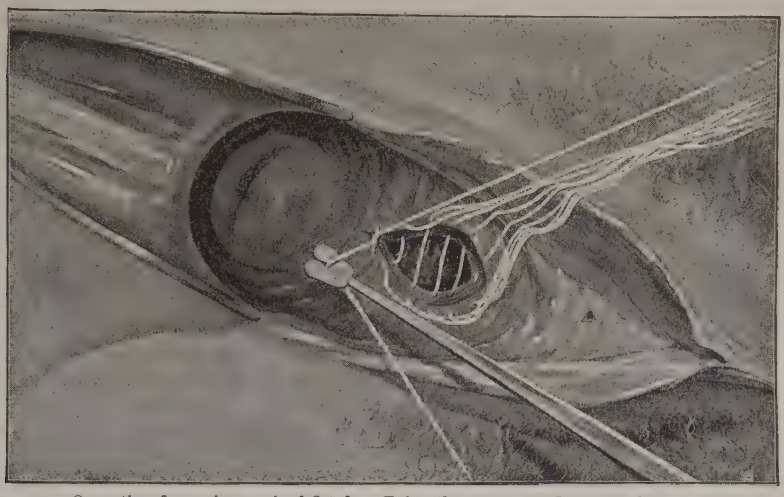


The course of the needle in passing sutures: *B*, bladder surface; *V*, vaginal surface. (Jewett and Polak.)

mucous membrane into the bladder and reinforcing it by another flap from the same source. (See under Hypospadias—Diseases of the Urinary Organs.)

The bladder may be dissected up from the uterus and from the vagina through an incision along the posteror margin of large fistulæ situated high up and its base drawn downward and forward and sutured to the freshened anterior margin of the fistula so as to close the latter (Kelly). In very

Fig. 894.



Operation for vesico-vaginal fistula. Tying the sutures. (Jewett and Polak.)

severe cases the bladder may be exposed by a suprapubic incision, the peritoneum drawn up, and the fistula reached in this manner, or the bladder may be opened as in ordinary suprapubic cystotomy and the fistulous opening sutured from within. Sometimes the vaginal portion of the uterus may be used to close the opening. In operating upon fistulæ involving the uterine cervical canal, wounds of the ureter must be avoided. The most difficult of all cases are those in which the ureter itself is involved in the fistula. In cases of a lateral opening in the ureter near its orifice the remaining part of the canal should be laid widely open down to the base of the bladder. The large opening thus created may be closed by one of the methods already described. Fistulæ which do not admit of cure by other operations have been treated by closing the introitus of the vagina and making the vaginal cavity practically a part of the bladder. This operation is suitable only for women of advanced life who have ceased to menstruate, as the admixture of the menstrual blood with the urine would be apt to result in a severe cystitis. A preliminary vaginal hysterectomy would remove this objection.

After-Treatment.—After operations upon vesical fistulæ the bladder should be drained by a permanent catheter, or the water drawn off every two hours. In operations for rectal fistulæ the sphincter should be thoroughly dilated, the bowel contents kept very soft with laxatives, and the diet limited to articles which will give the least amount of fecal residue. The plan of confining the bowels by opiates, formerly in use, is not so sat-

isfactory. In recto-vaginal fistulæ which extend very low down the sphincter and the narrow band of tissue between the vagina and the anus should be divided and the fistula converted into a complete perineal laceration, which can then be closed in the usual way. The vagina needs very little attention after these operations, a light packing of iodoform gauze being the best dressing, but this should be changed daily. Irrigation of the vagina is not employed unless there is some discharge from the uterus. The patient must not be allowed to sit up in bed for at least a fortnight, and then the stitches may be removed. Very frequently partial union only is obtained, and several operations are necessary to close the fistula.

Cicatrices.—As the result of extensive inflammation and sloughing during parturition, cicatrices are often seen in the vulva or the vagina, particularly in the latter, and sometimes they almost completely occlude the passage. The cicatrices may be treated by free incision, with care not to injure the surrounding parts. If extensive raw surfaces are left by the operation, an attempt should be made to cover them by sliding flaps of mucous membrane or by suturing the wounds; extensive bands can thus be disposed of and primary union obtained.

INFLAMMATION.

Vulvitis, Vaginitis.—Inflammation of the vulva and of the vagina is very frequent, the former usually being secondary to the latter. The commonest of these infections are the venereal, either gonorrhœal or chancroidal. A **vulvitis**, however, may be the result of any irritating discharge from the vagina, the leakage of urine from the bladder in cases of incontinence, or mere neglect of cleanliness. In the majority of such cases it can be subdued by thorough cleanliness. **Bartholin's vulvo-vaginal glands** may become inflamed and form **labial abscesses**, which require treatment by incision and thorough extirpation of the lining membrane, or a recurrence is certain to take place. (See page 1183.)

Tuberculosis more commonly attacks the vagina than the vulva, being generally secondary to uterine tuberculosis. It appears in two varieties. The first is more or less extensive ulceration with blue undermined edges, a pale base covered with flabby granulations, and a slight, thin discharge. The second form is the nodular or lupous variety, resembling very much lupus of the mucous membranes elsewhere. It can be distinguished from epithelioma by the lesser induration and by the presence of dark bluish nodules at a little distance from the ulceration. The treatment of these lesions consists in their thorough excision or destruction by the cautery. Plastic operations may be necessary afterwards, to obviate the contractions and other deformities which ensue. The results of treatment are not satisfactory, for recurrences are very frequent and the patient is generally tuberculous otherwise. If the cases are neglected, however, very extensive destruction of the parts may be produced by ulceration, and vesical or rectal fistulæ may form. The inguinal glands will usually be found affected.

Endometritis.—Inflammation of the lining membrane of the uterus is termed endometritis, and may affect either the body or the cervix, or both. Endometritis may be the result of gonorrhœal or tubercular infection, but

is most commonly due to septic inoculation by instruments used in uterine examinations or for the production of abortion, or to sepsis from careless midwifery. Tuberculous endometritis is usually secondary to tuberculous salpingitis. The predisposing causes are subinvolution of the uterus following childbirth, malpositions of the organ, and anæmia. The symptoms are a profuse discharge of clear mucus or a muco-purulent fluid, menorrhagia, metrorrhagia, dysmenorrhœa, sterility, various nervous symptoms, pain in the back, and tenderness in the uterus. In the acute septic cases there is a rise of temperature.

With the acute infections, excluding the gonorrhœal, the surgeon is seldom brought in contact, although hysterectomy has lately been recommended for acute septic endometritis after labor. The chronic form results in certain changes in the uterine mucous membrane, irritation and ulceration of that membrane in the vaginal portion, painful obstruction to the menstrual flow from the swelling of the uterine lining, and menorrhagia. The changes in the uterine mucous membrane may be simply catarrhal, or granulations may cover the mucous membrane and sometimes assume a fungoid form, each papillomatous outgrowth containing a loop of a blood-vessel covered by a single layer of epithelial cells. This *fungoid degeneration* of the endometrium especially gives rise to metrorrhagia. There is also an *exfoliative endometritis* in which the membrane is detached in sheets. *Tuberculous endometritis* may be miliary, or a general cheesy degeneration. It is usually found at the fundus. Cicatricial contraction of the ulcers may result in stenosis of the canal and the distention of the uterus with purulent tubercular material.

Treatment.—It is very difficult to treat endometritis effectively. The patient should be kept in bed for a week or a fortnight at the beginning of treatment. Any malposition of the uterus must be corrected, and any stenosis of its canal dilated. Meanwhile every care must be taken to improve the general health of the patient by proper diet, abundant rest, and perhaps a change of scene. Abstention from sexual intercourse is absolutely necessary. Hot vaginal douches, with a temperature of 110° F. (43° C.) or higher, if the patient can endure it, will contract the vessels and diminish the congestion. In ordinary cases the application of pure carbolic acid or of strong tincture of iodine to the uterine canal will bring about an alteration of the mucous membrane for the better. In severe cases the cervix must be dilated, and the uterine mucous membrane entirely removed with a sharp

Fig. 895.

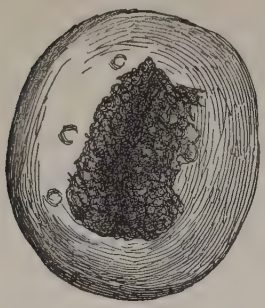
Sharp uterine curette.

curette. (Fig. 895.) In cases of fungoid degeneration this treatment is especially indicated. After the curetting, hemorrhage is controlled by tincture of iodine applied with cotton on an applicator, and the cavity of the uterus is thoroughly packed with iodoform gauze, which is allowed to remain in place for several days. The dilatation and curetting must be done with full antiseptic precautions, for fear of causing salpingitis or peritonitis, and

also to gain the full advantage of the treatment. After the removal of the gauze an Outerbridge wire intra-uterine stem is to be inserted and worn for some weeks in order to secure good drainage, and the intra-uterine applications are to be made at gradually lengthening intervals. If a cure is not obtained, the possibility of a chronic salpingitis discharging through the uterus is to be borne in mind.

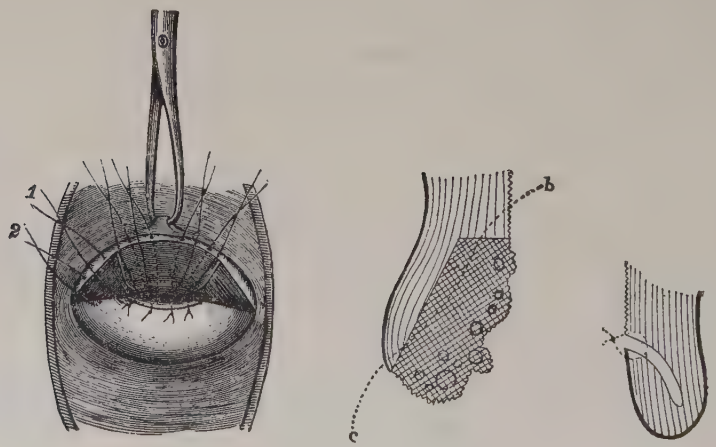
Inflammation of the cervical mucous membrane is recognized by the cysts in the Nabothian glands which result from it, and by erosions of the os. The term erosion (Fig. 896) is given to a bright red papillomatous condition of the mucous membrane resembling an ulcer covered by small velvet-like granulations, but there is no true ulceration here, the epithelial layer being intact. An eversion of the cervical mucous membrane due to a laceration has a somewhat similar appearance at times, and may be mistaken for it. The **treatment** of this inflammation is similar to that for endometritis of the fundus, but the cysts should be punctured as soon as they form. In obstinate cases the vaginal portion may be split laterally (Schroeder's operation, Fig. 897), the internal cervical mucous membrane extirpated, and the mucous membrane of the vaginal surface turned in and secured by sutures so as to cover the raw surface. The use of caustics for erosions is dangerous, from the possibility of setting up malignant disease.

Fig. 896.



Erosion of cervix. (Ruge and Veit.)

Fig. 897.



A *B* *C*

Schroeder's excision of cervical mucous membrane: *A*, sutures introduced in the upper flap, the lower flap having been sutured; *B*, the shaded portion shows the extent of excision, and *bc* shows the course of the suture; *C* shows a suture tightened and the flap inverted. (Pozzi.)

The diagnosis of tubercular endometritis is uncertain and its treatment unsatisfactory. Gonorrhœal endometritis is discussed in the chapter on Gonorrhœa.

Metritis, or inflammation of the uterine tissue, is not likely to come under the surgeon's care, except that hysterectomy may be required for a septic metritis after labor.

PELVIC PERITONITIS.

Pelvic peritonitis is the result of septic infection in parturition or occurs as the consequence of pyosalpinx and salpingitis. It may be tuberculous, following tuberculosis of the genitals. In the very acute cases the patient has intense pain, a high temperature, and chills, and the case may terminate rapidly in septicæmia or a general peritonitis. Or the disease may be subacute, with less marked but similar symptoms, which may be so slight that the patient will be up and about, the irregular slight fever not being noticed. In still other cases the disease runs almost a latent course, slowly progressing from the infected tubes. The acute form is usually seen as the result of infection in parturition, in criminal abortions, or in severe gonorrhœal infection.

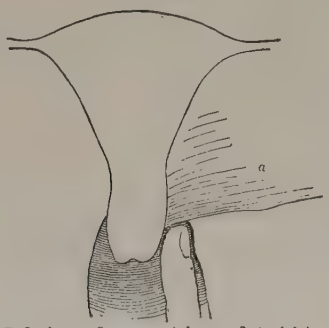
Treatment.—For this form but little can be done beyond the application of a cold coil to the abdomen and the administration of morphine. In the subacute form the use of hot vaginal douches, rest in bed, laxatives, and tonics are indicated. Thorough treatment may prevent the formation of adhesions, and the exudate may become absorbed, leaving the parts in a fairly healthy condition. In the latent form the diagnosis will usually not be made until it is too late to accomplish much by these means. The persistent use of hot douches, however, with the application of iodine to the vault of the vagina, and packing the vagina with tampons wet with boroglyceride, will often ameliorate the symptoms. In the two latter forms a chronic salpingitis is at the base of the trouble, and a cure can be obtained only by the removal of the tubes by an operation.

PELVIC CELLULITIS.

Inflammation of the cellular tissue of the pelvis, especially that of the broad ligament, is usually secondary to some inflammation of the genitals, but is not a very common complication, the majority of cases formerly thought to represent this disease being instances of peritonitis. In most cases, also, the peritoneum is involved as well as the cellular tissue, and it is impossible to distinguish between the two. Cellulitis, however, does occasionally accompany a septic inflammation of the uterus or of the vagina, and sometimes results in abscess of the broad ligament. These abscesses are to be distinguished from intraperitoneal masses of adhesions and pus collected about the inflamed tubes and ovaries by the fact that they lie rather low down in close contact with the upper part of the vagina, especially on the sides of the latter (Fig. 898), whereas tumors formed by inflamed tubes are generally higher up (Fig. 899), or occupy Douglas's cul-de-sac. The symptoms of cellulitis are pelvic pain and tenderness, with the constitutional indications of infection occurring during the course of septic disease of the genitals. Examination will reveal tenderness on one or both sides of the uterus, which will be somewhat fixed by the exudate. The inflammatory mass may attain considerable size. When pus forms fluctuation

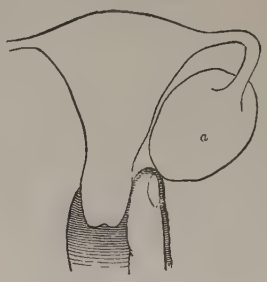
may be absent, but there will usually be some œdema or boggy feeling of the upper vaginal wall. If left untreated these abscesses may burst into the vagina, rectum, or bladder, or externally along Poupart's ligament. If an abscess of considerable size has formed it is generally difficult, if not impos-

Fig. 898.



Relations of parametric exudate (*a*) to the uterus. (Byford.)

Fig. 899.



Relations of pyosalpinx (*a*) to the uterus. (Byford.)

sible, to determine whether it is in the cellular tissue or whether there is an intraperitoneal collection of pus around the tube.

Treatment.—The treatment of abscesses in this situation is prompt evacuation as soon as the pus can be recognized, an exploratory puncture being made in doubtful cases by the aspirating needle introduced into the upper part of the vagina, one finger being placed in the rectum, if necessary, as a guide. If pus is reached the needle should be left in place as a guide, and a sharp-pointed pair of scissors thrust through the vaginal mucous membrane to the cavity. A dressing forceps will easily follow this instrument, and the opening should be dilated by spreading the branches. A drainage-tube is introduced and secured in place by a stitch through the vaginal mucous membrane, and should be kept in place until the discharge ceases.

TUMORS OF THE VAGINA AND VULVA.

The **clitoris** is liable to hypertrophy, but tumors of the organ are rare. Many varieties of neoplasm have been observed, the most common being fibroma, angioma, and epithelioma. They are treated by extirpation, for complete removal of the organ does not disturb the sexual functions. Clitoridectomy was once advised as a cure for masturbation, but has been found useless. The separation of adhesions about the organ may, however, allay sexual irritation.

Fibrous and fatty tumors and angiomata, cysts and papillomata, form the great majority of the benign tumors of the vulva and vagina. **Angioma** is usually external, and occurs in infants. **Fatty** tumors develop in the labia, being formed of a soft, almost myxomatous, tissue, and sometimes attain an enormous size, being more or less pedunculated. (Fig. 900.) **Sebaceous cysts** are found on the outer surface of the labia. **Retention cysts** develop in **Bartholin's glands**, and also in the **mucous glands** (Fig. 901) in the vulva and vagina. The latter seldom attain a size large enough to be of clinical importance. Cysts of the vulvo vaginal glands are

situated in the substance of the labium majus near its posterior border, and even when large retain more or less of its shape. They are generally caused by infection of the ducts, especially by gonorrhœa, and the duct is not always completely obstructed, so that under strong pressure part of the contents of the sac may be evacuated. These cysts cause slight symptoms unless they are large or unless they suppurate (Fig. 902), when there is great pain and swelling, motion of the thigh becoming painful and adduction impossible, while micturition may be impeded by the œdema.

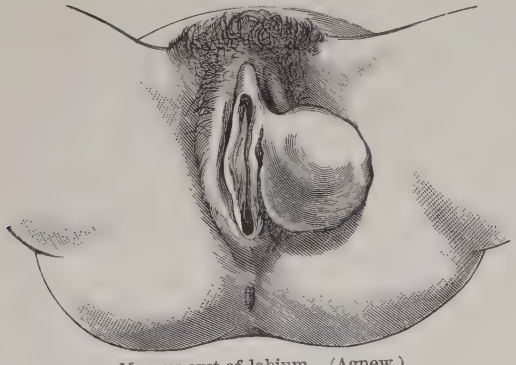
Fig. 900.

Fibrolipoma of labium majus. (Case of Dr. J. B. Deaver.)

The **treatment** of these cysts is incision of the mucous membrane covering them, and their complete enucleation. When suppuration has occurred, forming a vulvo-vaginal abscess, the same method should be adopted if possible; but if the parts are too adherent to the capsule, the cavity should be thoroughly laid open, as much of the capsule as possible enucleated, and the wound packed with gauze and compelled to heal from the bottom. The small mucous cysts seldom require treatment other than incision and the application of strong carbolic acid or some other mild caustic to the interior of the sac.

Papillomata of the vulva (Fig. 903) are originally soft, moist growths, covered with a cheesy discharge, but when exposed to the air they become hard. They are usually multiple, and result from venereal infection in the

Fig. 901.



Mucous cyst of labium. (Agnew.)

Fig. 902.

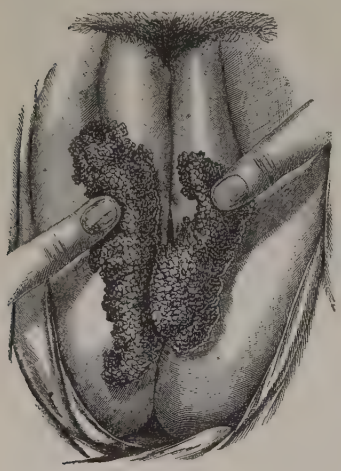
Suppurating cyst of vulvo-vaginal gland. (Madden.)

vagina or the vulva. **Treatment.**—The cure of the disease usually causes the disappearance of the papilloma. Thorough cleansing of the parts, with the application of a dry dusting powder, such as calomel, will often effect a

cure. When they have existed for some time their tissues become hardened and fibrous. The mild caustics, such as alum or acetic acid, will destroy the soft growths. If they recur, fuming nitric acid should be applied and their bases thoroughly destroyed. In very dense, fibrous warts excision may be necessary.

Congenital cysts originating from Gärtner's duct are occasionally found in the vagina, but are so rare as to be of little clinical consequence.

Fig. 903.



Papilloma of vulva. (Agnew.)

Fibromyomatous tumors grow from the vaginal wall, usually becoming pedunculated, and sometimes protruding from the vulva. The vagina may also be occupied by pedunculated tumors of the uterus, and in any case of vaginal polypus the attachments of the tumor should be carefully examined.

Malignant Tumors.—Primary malignant tumors of the vulva and vagina may be either sarcoma or epithelioma. Secondary tumors of the vagina are common, as it is often involved by direct extension of the disease from the cervix uteri or the rectum. Primary **sarcoma** is not common, but when it occurs it develops in the deeper parts of the mucous membrane of the vagina or in the connective tissue of the labia, although in the latter it is even rarer than in the vagina. It forms small ovoid tumors, at first covered with mucous membrane, but soon ulcerating, and then often vegetating and filling the vagina with cauliflower masses like papillomata. In the later stages hemorrhages are common, and the discharge is very offensive. The diagnosis from epithelioma can seldom be made, as the tumors are rarely seen before the advanced stages, when the resemblance is very close. **Epithelioma** of the vulva and vagina begins as hard, flat nodules, ulcerating early or beginning as ulcers, and resembling very much in their physical characteristics the epithelioma of the lips. The course is usually a chronic one, the induration preceding the ulceration as they extend. They tend at first to spread superficially, but when they attack the septum between the vagina and the bladder or rectum they may produce fistulæ into either of these organs. Occasionally they assume a papillomatous growth and produce large cauliflower masses, which are very friable and bleed very easily. More rarely a carcinoma may develop from Bartholin's glands, in which case it may reach a considerable size before ulceration takes place. The inguinal glands are involved very early when the tumor is situated at the vulva, and sometimes in vaginal cancer. The latter infects the pelvic glands. There are, as a rule, no symptoms in the early stages, not even pain being occasioned. In the later stages there is a vaginal discharge of blood, pus, and foul serum, and the symptoms of fecal or urinary fistula with severe pain.

Syphilitic disease of the vulva and vagina frequently simulates malignant tumors, but in the former case there are syphilitic lesions elsewhere,

the induration and fixation of the parts are less, the ulcers have not the characteristic, brittle, readily bleeding granulations, and the tendency is towards destruction rather than production of new tissue. A short and determined course of antisyphilitic treatment should be tried in doubtful cases, and a portion removed for microscopic examination.

Treatment.—Complete extirpation is the only possible treatment of these malignant growths, but it is rarely feasible, on account of the great extent of the disease when first seen. Extirpation should be limited to movable tumors, as there is no hope of a radical cure after they have become fixed to the deeper parts, and decided enlargement of the inguinal glands also contra-indicates operation. Vaginal cancer should be thoroughly examined with the finger in the rectum and a sound or a finger in the bladder. Involvement of these organs need not prevent an attempt at extirpation, as the openings which may be made in them can be closed afterwards. But any extension of the disease into the cellular tissue around the vagina or in the broad ligament, as shown by adhesions or thickening of the parts, would contra-indicate operation, because a radical cure would be impossible. In tumors limited to the vaginal mucous membrane, the latter and the submucous tissue should be thoroughly and widely cut away. Diseased portions of the bladder and rectum are to be removed. The hemorrhage is usually free, but can be controlled by mass ligatures or by clamps and pressure. In operating for epithelioma of the vulva, a thorough extirpation of the inguinal glands on both sides is to be added, even if they are not perceptibly enlarged, as the glandular tumors are more frequently the cause of death than a local recurrence. Various plastic operations may be required to cover the defects made by the excision. Excision is to be preferred to the use of the cautery, on account of the thoroughness and the greater exactness with which the work can be done. In inoperable cases improvement can sometimes be obtained by thorough cauterization of the ulcerating surface after removing the softer tissues with the curette, which lessens the hemorrhage and discharge, and sometimes even the pain.

Elephantiasis of the vulva is due to filaria-infection, lymphatic obstruction, or the solidification of a chronic œdematous swelling caused by the inflammation of the parts. In the tropics immense tumors are found, and even in this country the swelling may be sufficient to compel operation. The skin and subcutaneous tissues are thickened and œdematous, and the surface is usually papillomatous, with hypertrophy of all the constituents of the skin. The tumors are not so hard as epithelioma, and the structure of the altered skin is different. The swollen parts may be excised, hemorrhage being arrested by clamps and pressure, and the edges of the wound brought together with sutures.

Hydrocele in the Female.—Occasionally a process of peritoneum accompanies the round ligament down through the canal of Nuck into the labium majus, and it may become shut off from the general peritoneal cavity and fill up with serous fluid, forming a cyst to which the name of hydrocele is given on account of its analogy to scrotal hydrocele. These cysts are usually pear-shaped, having a neck running up towards the inguinal ring, which distinguishes them from cysts of Bartholin's glands. The diagnosis from

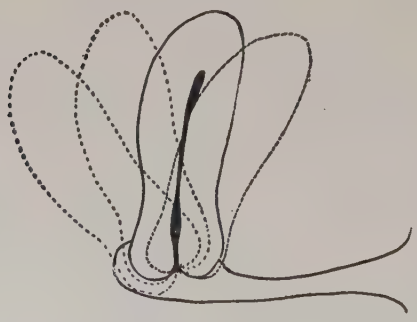
hernia is made by the irreducibility of the tumor, by the absence of impulse on coughing, and in some cases by its translucency. These cysts may be treated by aspiration and injection with carbolic acid, as in the male, or by extirpation. Occasionally the cysts communicate with the peritoneal cavity, and in such cases the fluid can be pressed back into the abdomen. Varicose veins occur in the vulva, but differ from varicocele in the male, only the superficial veins being affected. They can be cured by multiple ligation or partial extirpation.

Vaginismus.—Vaginismus is a spasmodic contraction of the sphincter and even of the muscular fibres of the vagina. It is common in newly married women as the result of the traumatism of beginning intercourse, especially if they are of a neurotic temperament. The spasm in some cases is very violent and painful, and extends to the sphincters of the bladder and rectum, so that evacuation of either organ is accompanied with intense pain. In such cases the slightest touch upon the vulva may initiate the spasm. The spasm is often due to a small ulcer or fissure between the fragments of the hymen, or to hyperæsthesia of some of the fragments or carunculæ; in other cases the cause appears to be a neuralgic condition of the nerves of the vestibule. **Treatment.**—The treatment consists in abstention from sexual intercourse, rest in bed, and then slow and cautious dilatation, beginning with glass plugs small enough to be introduced without pain, for if the stretching be carried so far as to cause pain a relapse will be produced. In the worst cases excision of the carunculæ must be tried, and in some cases the pudic nerve has been divided with success.

DISPLACEMENTS OF THE UTERUS.

The uterus normally lies in a position of slight anteversion, its axis being straight and about at right angles with the axis of the vagina and the fundus just below the upper border of the pubic bones, and separated from it by a slight interval. A full bladder throws it backward, and a

Fig. 904.



Normal mobility of uterus. (Mundé.)

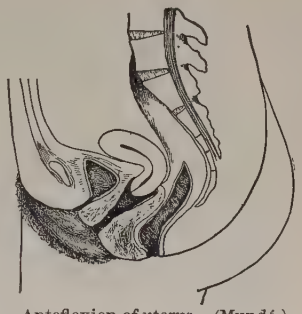
Fig. 905.

Retroversion of uterus. (Mundé.)

distended rectum pushes it forward. The normal uterus is quite movable, and in some persons extremely so, and displacements should be considered pathological only when they are extreme or when they produce symptoms. (Fig. 904.)

The rotation of the uterus about a transverse axis is called **version.** The uterus may remain at a proper level, but rotated about a transverse axis so that the fundus will be thrown backward (Fig. 905) or forward. The uterus may be displaced from its normal position in the pelvis by simple descent, and, as it must follow the natural curve of the axis of the pelvis in descending, the fundus must be thrown backward, making a **retroversion.** A bending of the organ is termed a flexion. A bending backward is a **retroflexion,** and the fundus passes into Douglas's cul-de-sac. In **anteflexion** the fundus turns forward so that it presses upon the bladder (Fig. 906), or even becomes prominent in the vagina anterior to the cervix. **Lateral flexions** of the organ are also seen, but they are less common. Flexion and version may be combined, as when a uterus which is anteflexed is then rotated backward on a transverse axis so as to become retroverted, or when it is retroflexed and at the same time retroverted. The uterus may also be displaced as a whole, without version or flexion, by the pressure of tumors, the traction of adhesions, or the yielding of its ligaments.

Fig. 906.



Anteflexion of uterus. (Mundé.)

In elderly women displacements, especially prolapse, are very frequent because of the absorption of fat from the pelvis and perineum, and the consequent loss of support to the organs, as well as the atrophy of the fibrous tissues and the ligaments. Versions of the uterus are due to laxity of the ligaments which should keep it in position, to the pressure of a tumor which pushes the organ out of place, or to adhesions which draw it to one side, and in rare cases a congenital shortening of the anterior vaginal wall holds the cervix forward and causes a retroversion. Flexions, on the other hand, are often congenital, being due to insufficient development of the anterior or posterior wall or of one lateral half, the undeveloped portion forming the concave side of the curve. Flexion can be produced or exaggerated by the same causes that produce version, and also by an unnatural softening of the uterine tissue, especially in cases of subinvolution, where the large size of the uterus is an additional cause of the displacement. The effect of version upon the uterus is to obstruct its venous circulation and thus increase its liability to inflammation.

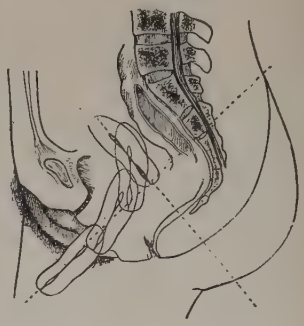
Prolapsus.—Descent of the uterus, or falling of the womb, is called prolapse, or procidentia. It may be due to laxity of the ligaments and absorption of the fat in the pelvis, especially if the uterus is heavy from subinvolution or the presence of a tumor. Laceration of the perineum is the most common cause. The displacement is therefore most common in women who have borne children, and in advanced life, but it may be seen in virgins even before the thirtieth year, as the result of falls upon the buttocks or straining in lifting heavy weights. The uterus may be only slightly below its normal position or may pass entirely out of the body and hang between the thighs, covered with the everted vagina. (Fig. 907.) In such cases the mucous membrane becomes greatly thickened and hardened, resembling

skin, and it is often ulcerated. The principal complaint of the patient even in these severe cases may be the disturbance of function of the bladder, which is rolled out with the anterior vaginal wall so as to form a pouch and render it liable to cystitis. As the uterus descends it follows the curve of the pelvis and is somewhat retroverted. (Fig. 908.) A careful examination

Fig. 907.

Extreme prolapsus uteri. (Case of Dr. R. Abbe.)

Fig. 908.



Prolapsus uteri. (Mundé.)

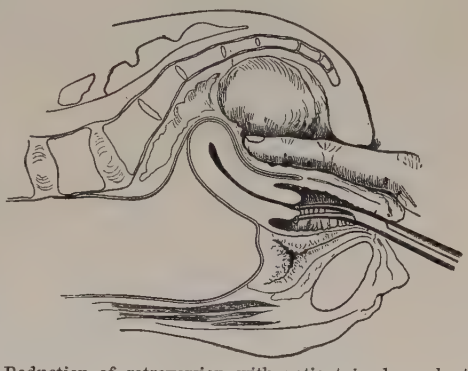
is needed to distinguish between these cases and simple retroversion, especially as the mere turning back of the fundus in retroversion carries the cervix forward and nearer the introitus, so that it is easier to reach it with the finger, and it seems to have prolapsed. In the slighter grades of descent it may be necessary to examine the patient in the standing position in order to appreciate the amount of prolapse. The cervix is often elongated to twice its natural length in cases of prolapse, and a careful measurement should be made by inserting the sound up to the fundus, in order to ascertain how much of the apparent displacement is due to a real descent of the entire organ and how much to the elongation of the cervix.

Symptoms.—The general symptoms produced by displacements of the uterus are pain in the back, caused by the dragging on the various ligaments or merely by the congestion of the organ, and pains are occasionally felt running down the legs, owing to pressure on the sacral plexus. Constipation and vesical irritation may be caused if the uterus presses upon the rectum or bladder. Menstruation may be very painful, the exit of the flow being obstructed by the malposition of the uterus. Mechanical dysmenorrhœa is more frequent in flexion than in version, but the congestion of the uterus in extreme version results in menstrual disturbances, such as too frequent menstruation, too prolonged and too abundant flow, and an increase in the various general symptoms of menstruation. Endometritis is usually present, and adds its symptoms to those mentioned. Many of the symptoms of displacement are really due to the inflammation or the adhesions which accompany or cause the malposition, and may sometimes be relieved by treatment directed to these conditions even without correction of the displacement.

Treatment.—Replacement.—The malposition of the uterus may be reducible by pressure with the finger in the vagina or rectum, drawing

downward on the cervix with a tenaculum at the same time, the patient being placed in a position to facilitate the movements. Thus, in a retroflexion or retroversion the patient is to be placed in the knee-chest position with the hips elevated. (Fig. 909.) Instruments have been invented for this purpose, but they are not considered safe. The uterine sound may be used during reduction, but only to hold the organ in position after it has been replaced as far as possible by the finger, for perforation of the uterine wall might easily occur if the pressure necessary to move the organ were to be exercised with that instrument. When the abdominal wall is lax the fundus of the uterus can often be reached by the palpating hand outside and carried into its proper position. If pregnancy takes place in an organ out of position very severe symptoms may result, and miscarriages from this cause are frequent, but this may be prevented if the condition is recognized early enough to allow of replacement of the organ before its large size has fixed it in its faulty position. If adhesions prevent the reposition of the uterus, they may be stretched by constant and persistent attempts at replacement carried out daily or weekly for a long period, their absorption being hastened by the daily use of the hot douche and other medical measures. What is gained each day may be maintained by packing the vagina with cotton balls so placed as to hold the uterus in position.

Fig. 909.

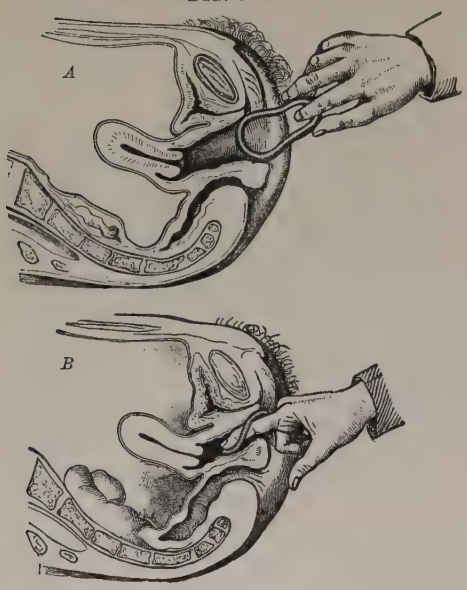


Reduction of retroversion with patient in knee-chest position. (Madden.)

Pessaries.—When the uterus has been replaced and shows a tendency to return to its malposition, an instrument known as a pessary may be inserted in the vagina in order to retain the organ in its proper place. In cases of anteversion or anteflexion a pessary can accomplish but little, as it must then take its bearings upon the soft part of the vaginal wall, but in backward displacements a properly placed pessary curves forward and the lower end rests against the pubic arch in such a way as to give a tolerably firm support. Some pessaries act only by their size, forming a large mass on which the uterus rests without giving definite support in any one direction. The Hodge pessary of hard rubber is the most generally useful, and when heated can be bent to any required shape. Pessaries must be made to fit the parts exactly. They should not cause pain when introduced, and there should be enough space around them to permit the finger to be passed between the pessary and the vaginal wall on all sides. A daily vaginal douche is necessary when a pessary is worn, and the patient should always be instructed how to remove it in case of accident. The introduction of the instrument, however, should always be made by the physician. To introduce the Hodge pessary, place the patient upon the side, insert the broad end of the instrument in the introitus, and press back the perineum with it

until it enters without pressure upon the urethra. (Fig. 910, *A*.) The pessary then readily slips into the vagina, where it must be turned around into proper position. The index finger is introduced, and the upper bar is placed behind the cervix. (Fig. 910, *B*.) The use of pessaries must be discontinued if it is found that in spite of careful adjustment ulceration is caused by their pressure, as there is then danger of septic infection and of malignant disease. Pessaries which are supported by a band passing up to a waistband are uncomfortable to wear, and when they are efficient in holding the uterus in position the pressure is usually so great that ulceration is almost certain to occur, so that their use cannot be recommended. A pessary is only palliative; it does not cure. In the majority of cases of displacement of the uterus severe enough to warrant the use of a pessary a cure can be obtained by an operation, but in some cases it is necessary to postpone the operation on account of the patient's health or for other reasons, and then pessaries are a useful temporary expedient. Sometimes a retroversion pessary will relieve the symptoms of anteversion or anteflexion, by lifting the uterus and lessening the pressure upon the bladder, which is the most urgent symptom of this condition.

Fig. 910.



Introduction of Hodge pessary. (Madden.)

Operations for Retroversion and Prolapse.—Many operations have been introduced for the correction of displacements of the uterus.

Ventral Fixation.—For simple descent or prolapse, as well as for backward displacements of the uterus, hysterorrhaphy, or ventral fixation of the organ, may be done, securing the fundus to the anterior abdominal wall just above the pubes. A small median laparotomy wound is made, the fundus is drawn close to the abdominal wall, and deep sutures are passed through the edges of the abdominal wound and the fundus; or buried sutures are inserted through the fundus and the deeper layers of the abdominal wound.

Shortening the Round Ligaments.—*Alexander's operation* for shortening the round ligaments may also be employed for these conditions, as follows. The ligaments are exposed by a dissection at the external inguinal ring, and are drawn out of the ring, the uterus being lifted up at the same time by an assistant's finger in the vagina, as the round ligaments may not be strong enough to bear the strain of the organ by themselves. It is generally advisable to incise the inguinal canal somewhat in order to draw the ligaments well down. The sheath of peritoneum which accompanies the

ligament into the canal is frequently opened in the dissection. The serous membrane should be stripped off the cord with forceps, and it usually peels back readily. If a large opening is made, it should be closed by a catgut suture. The round ligaments may be stitched to the edges of the ring, but the best method of securing them is that suggested by Abbe. He uses the ligament itself as a suture material, and draws it back and forth through the pillars of the ring by a loop of thread on a large needle on a handle like the "carrying thread" for passing wire sutures. The round ligaments may also be shortened by an *intraperitoneal operation.* A laparotomy is done, the ligaments are drawn up, and a loop is made in each at the centre and the loops are secured by sutures passed through the overlapping parts. This last operation is suitable for cases in which strong adhesions prevent replacement without laparotomy, or when laparotomy is being done for some other purpose, such as the removal of a tumor. It seems unnecessary to undertake a laparotomy merely to shorten the ligaments.

Whatever method be employed, it is also necessary to repair the perineum if lacerated, and to reduce the size of the vagina if dilated and prolapsed, in order to avoid any cause which may tend to reproduce the deformity. Ventral fixation is not suitable for young women in whom pregnancy is still possible, because it interferes with the development of the uterus, rupture of the uterus during a subsequent labor having followed in more than one case. Alexander's operation will fail occasionally because the round ligament cannot be found or because it breaks when it is drawn out.

Colporrhaphy.—When the vagina has been everted with a prolapsed uterus the canal becomes very greatly stretched, and it is necessary to reduce its calibre by colporrhaphy. This is done by making an oval denudation on the anterior or posterior wall or both, each denuded area being closed for itself, its edges being united by sutures across the raw surface. This operation is the equivalent of cutting a segment out of the vaginal wall at these points. Some have suggested denuding a portion of the vaginal wall anteriorly and posteriorly and bringing the raw surfaces together across the vagina by a series of sutures, forming a sort of pillar in the centre of the vagina. The results obtained by these methods are good, but the central pillar alone is not sufficient to hold the uterus in place, being apt to yield to the pressure in time. Another method consists in passing a series of buried sutures circularly around the vagina just under the mucous membrane, and thus constricting the canal so that the uterus cannot descend.

Hysterectomy.—In very severe cases of prolapse of the uterus removal of the organ at the vulva is an excellent method of treatment. The operation, however, is not easy, in spite of the low position of the uterus, on account of the great extent to which the bladder covers the fundus in the anterior wall of the prolapse. Hysterectomy, however, does not entirely correct the condition found, and leaves the pelvic floor very weak; when it is done, therefore, the perineum should also be restored, and the rectocele and cystocele treated by plastic operations.

Operations for Anteversion.—No really successful method of operative treatment for anteversion has yet been devised. **For Retroflexion.**—

Retroflexion of the uterus, if the organ is not too rigid and the fundus can be bent forward, may be overcome by vaginal fixation, an incision being made along the cervix at the vaginal junction, the bladder stripped up from the anterior wall of the organ, and the fundus then thrown forward with a sound or by a finger introduced into the peritoneal cavity through a small wound in the peritoneum. The fundus is caught by a curved needle, and deep sutures passed through it and through the tissues on each side of the cervix, securing it firmly to the anterior vaginal wall. This operation is not devoid of danger, on account of the proximity of the bladder and ureters, and it is very dangerous to perform it, as has been recommended by some, without first incising the mucous membrane and detaching the bladder. Retroflexion may sometimes be treated by the same methods as retroversion.

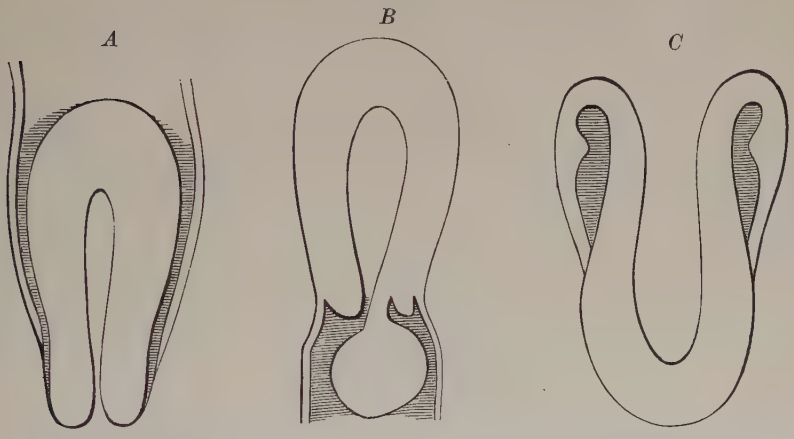
For Anteflexion.—As anteflexion is almost invariably due to a lack of tissue in the anterior wall of the uterus, little or nothing can be done to correct the malposition. But if sterility or dysmenorrhœa is present owing to the acute flexion of the canal, these conditions may be relieved by incising the canal of the cervix backward, so as to split the vaginal portion. Another method of treatment consists in small multiple incisions of the os, with systematic dilatation of the canal and the wearing of an intra-uterine stem pessary. Pregnancy has been known to follow these measures.

Inversion.—Inversion of the uterus takes place as an accident in parturition, and it is also gradually produced by the traction of polypoid tumors attached near the fundus and expelled into the vagina by uterine contractions. The symptoms of inversion are profuse vaginal discharge and discomfort owing to the presence of the tumor in the vagina, and sometimes hemorrhage from the surface of the inverted womb. The diagnosis is made by a physical examination. If the inversion is complete, the tumor will be continuous with the vault of the vagina on all sides, and the edge of the cervix can be felt high up and reversed—that is, directed upward instead of downward. If the cervix is not inverted but the fundus has descended through it, a finger or a sound can be passed into it along the sides of the tumor, but will be arrested just within at the point where the inversion occurs. (Fig. 911.) Bimanual examination will show an absence of the fundus in the pelvis, and the central depression produced by its inversion can sometimes be felt either through the abdominal wall or by the finger in the rectum. The possibility of partial inversion should be remembered in removing all polypoid tumors from the vagina, as one horn of the uterus is often drawn down through the fundus and appears to be part of the pedicle of the tumor. If the inversion is not reduced at once, adhesions form and reposition may be exceedingly difficult.

Treatment.—Reposition has been effected by means of a cup-shaped instrument secured to a long stem with a spiral spring, the fundus of the uterus being placed in the cup and the base of the stem and spring resting against the operator's chest. Gradual pressure is made upward, while the parts are steadied by one hand on the abdomen sunk well into the pelvis, where the depression in the upper surface of the uterus can sometimes be felt. It is wise to make a small laparotomy wound in order to break up adhesions and control the action of the instrument. If all attempts fail, the

cervix can be dilated and the inverted fundus amputated above the level of the internal os. Heavy sutures should be passed through the inverted portion before the fundus is cut away, for the thick uterine wall will spring up

FIG. 911.



Differential diagnosis of inversio uteri: *A*, prolapse; *B*, polypus; *C*, inversion. (Madden.)

out of reach as soon as it is divided. If the fundus can be partly reduced, Emmet suggests freshening the lips of the cervix and uniting them with sutures over the prolapsing fundus, to prevent any increase of the inversion. Vaginal hysterectomy is the final resource.

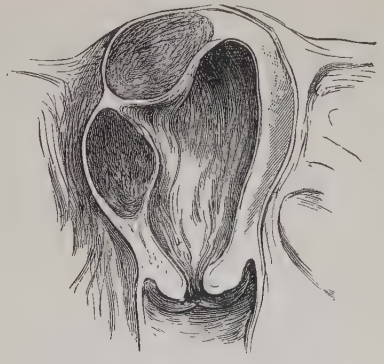
TUMORS OF THE UTERUS.

While **adenoma** is rarely found in the uterus as a large tumor, fungoid endometritis and the cysts of the Nabothian glands are microscopically adenomata. Sometimes large **myxomatous** polypi are found hanging in the vagina which originate in the endome-

FIG. 912.

Subperitoneal and submucous fibroids; uterus laid open. (Madden.)

FIG. 913.



Interstitial fibroids. (Agnew.)

trium, especially that of the cervix, and resemble the nasal polypi. But the only benign tumor of the uterus of clinical importance is the fibromyoma.

Fibromyoma, or **fibroid tumor,** begins as an encapsulated growth in the wall of the uterus, and as it enlarges works its way either towards the cavity of the organ or to its external surface. When the tumor projects into the cavity of the organ it is called a submucous fibroid (Fig. 912), and it may have a broad base or form a polypoid growth with a narrow pedicle. This is the least frequent variety. In over one-half of the cases it lies in the substance of the wall of the organ, and is called an interstitial or mural fibroid. (Fig. 913.) When situated upon the external surface of the uterus it may be a subperitoneal growth (Fig. 912), or may make its way outward at a part not covered with peritoneum. These tumors may be multiple, and they may acquire an immense size, especially when they undergo cystic degeneration. Their relations to the uterus are various. They may grow in the wall and expand the entire uterus as if it were enlarged by pregnancy. In other cases the uterus and the tumor are connected only by a long and narrow pedicle. The intraperitoneal tumors may be pedunculated or sessile, but the larger ones are, as a rule, attached to a considerable part of the surface of the organ. These tumors often reach a weight of thirty or forty pounds, and one has been reported of one hundred and forty pounds. They may extend up into the abdomen as high as the ensiform cartilage. We have removed a tumor which extended up to this point, filling the entire abdomen, and yet was connected with the uterus, which was of normal size, by a pedicle not thicker than a man's thumb. Fibroids sometimes vary in size, enlarging during the menstrual epoch or in pregnancy, and undergoing partial involution afterwards. Polypi have been known to enlarge and descend into the vagina during the menses, and to retreat up into the uterine cavity between the periods. A uterus containing fibroid tumors is usually so heavy that there is a tendency to retroversion and prolapse, but when the mass has attained a certain size it gains support from the pelvic walls, and then the organ and the tumors begin to ascend into the abdomen, as in the enlargement of a normal pregnancy. The extraperitoneal fibroids have more or less tendency to grow downward into the pelvis, and even when small they may cause much distress by pressure upon the rectum or bladder, or by compressing the nerves and blood-vessels against the pelvic walls.

Fibromyoma is liable to myxomatous changes or a mucoid degeneration producing large cystic cavities. The tumor may become infected through some uterine ulceration, and then rapidly breaks down and sloughs, causing sepsis. Sloughing is also sometimes the result of a twist in the pedicle of the tumor, which may be the elongated cervix uteri, the circulation being cut off. In rare instances these tumors undergo a sarcomatous or carcinomatous change, or are associated with malignant tumors, and a rapid spread of the malignant disease is the rule in such cases. More common is a softening due to telangiectasis of the blood-vessels or lymphatics.

The causes of these tumors are obscure. They are usually found associated with sterility, but whether as cause or as effect is uncertain. They are most frequent between twenty-five and thirty-five years of age, and the negro race is especially liable to them.

Symptoms.—The presence of a uterine fibroid does not affect the general health directly, but it may interfere mechanically with the bladder,

rectum, or other abdominal organs, especially when the tumor is large or becomes impacted in the pelvis. Fibroids may give rise to neuralgia, especially sciatica, by pressure on the nerves, and the interstitial or submucous tumors may cause backache and colicky uterine pains, especially at the menstrual periods. They also occasion hemorrhages from the uterus, at first a mere menorrhagia, but afterwards metrorrhagia as well. If they become inflamed or slough, a septic condition may be produced. The presence of a submucous fibroid is to be suspected from the abundant hemorrhage, that from the subperitoneal fibroids not being so marked. Quite common is the discharge of a serous fluid from the uterus, which may be very abundant and may be evacuated in gushes. It may be odorless or offensive. While a subperitoneal fibroid, or even an internal tumor, is no impediment to conception, the majority of women with fibroids are sterile, and when conception takes place miscarriage is very frequent.

Diagnosis.—Examination reveals a rather globular tumor, more or less firmly attached to the uterus, following the movements of the latter and drawing the organ with it when it moves, usually freely movable in the abdomen, often lobular or multiple, hard to the touch, and prominent below in the pelvis or above in the abdomen, according to the direction of its growth. When cystic degeneration takes place the tumor usually reaches the largest size and grows more rapidly than otherwise. Examination of the uterus with the sound will usually show that the canal is longer than it should be, the uterus having taken on a certain amount of growth or else having been elongated by the growth of the tumor to which it is adherent. The intra-uterine tumors may be felt by the finger if the cervix is dilated, and sometimes they protrude into the vagina, hanging by a long pedicle from the interior of the uterus. Examination of the interior of the uterus with the sound will sometimes give a clue, for the point where the pedicle is attached to the outer wall may be distinctly felt with the instrument. Palpation of the round ligaments, the tubes, and the ovaries is sometimes possible, and enables one to determine the side from which the tumor has developed and its relations to the fundus.

In the ordinary cases the diagnosis is easy, on account of the large size, free mobility, and hardness of the tumor, the hemorrhages, and the displacement of the uterus. The origin of the tumor in the pelvis and its attachments indicate its connection with the genitals. Percussion reveals a central area of dulness extending from the pubes up towards the umbilicus, and the sides of the abdomen are resonant unless ascites is present. It is distinguished from solid tumors of the ovary by its attachment to the uterus, but a fibro-cystic tumor may not be easy to differentiate from a large ovarian cyst, although it is usually of rather unequal consistency, some parts still remaining firm and hard. The shape of the abdomen is also different, being less full near the pubes and more pointed above, and the projection of more than one nodule of the tumor may be evident instead of an even, globular extension. The uterus rises into the abdomen only in distention from retained menses, in fibroids, and in pregnancy. The first is seen only before puberty, but particular pains must be taken to exclude the possibility of pregnancy. Fibroid tumors are hard if solid and tense if

cystic. If single, they present a globular or pear-shaped mass, usually movable, the uterus moving with them, but they may become fixed by adhesions or by growing between the layers of the broad ligament. The uterine sound generally shows a considerable increase in the depth of the uterine canal. The bladder may also be proved to extend upward upon their anterior faces by examination with the sound. The uterus is usually displaced upward. A subperitoneal fibroid tumor may be connected with the uterus by only a narrow pedicle, and may be quite freely movable independently of that organ even when the tumor is of large size. These tumors are often multiple, and then several hard masses may be felt connected together but independently movable.

Treatment.—A small fibroid which gives no symptoms requires no treatment, as the growth of the tumor is slow, and until it reaches at least the size of a man's fist, or causes decided symptoms, it should not be operated upon. Fibroids cease to bleed and become atrophied when the menopause arrives. When, therefore, a fibroid is first discovered at this time, and is troublesome only on account of hemorrhage, it does not require operation even if it is of considerable size, provided the hemorrhage can be reduced by the administration of gallic acid or ergot, by a thorough curetting of the uterine canal, or by electrolysis. The presence of the tumor, however, may delay the menopause for several years, and this fact must be given due weight in the selection of treatment. **Electricity** has been recommended for the treatment of fibroids, and some remarkable cures have been claimed. The general experience, however, appears to be that it lessens the hemorrhage, but does not always reduce the size of the tumor. The method most in use is known as Apostoli's, and consists in the introduction into the uterine canal of an electrode connected with the negative pole, the positive pole being attached to a large flat electrode of metal, covered with cotton, gauze, sponge, or clay, and placed upon the abdomen. A strong current of from 150 to 300 milliamperes is used, and the séances are repeated weekly. If used to check hemorrhage, the intra-uterine electrode is connected with the positive pole. If a good result is not obtained in a few sittings, the method should be abandoned.

Oöphorectomy.—When the tumor itself is not troublesome, or when the condition of the patient forbids more extensive operations, removal of the ovaries and tubes has been suggested, in order to control the hemorrhage by bringing on an artificial menopause. Theoretically the operation promised well, but practically it has been found that its execution is exceedingly difficult in some cases, and may require a very large incision on account of the unusual position of the ovaries and tubes, which may be carried high up into the abdomen by the growth of the tumor. The removal of the ovaries, moreover, does not always bring about the menopause, as instances have been known in which the hemorrhages from the uterus have continued for months or years after the operation. There can be no doubt, however, that the shock of oöphorectomy is less than that caused by the removal of a large fibroid. The operation is done by a median incision, the ovary and Fallopian tube on each side being ligated and cut away, and the abdomen closed as usual. Another palliative method of treatment consists in the

ligation of the uterine arteries from the vagina, but it is not suitable for large tumors or when the uterus is drawn high up in the abdomen.

Myomectomy.—Myomectomy is the name given to the removal of the tumors without ablation of the uterus. It may be performed through the vagina or by a laparotomy, the former being suitable for submucous and the latter for subperitoneal tumors, while the interstitial may be attacked from either direction. Submucous fibroids may be removed by the vagina if the cervical canal is dilated or distensible, and even when rigid it may be incised so as to give access to the growth. The operation consists in dilating the cervix widely, ligating the tumor at its base, and cutting it away. If the point of attachment can be clearly seen, the pedicle may be divided without ligation and a deep stitch taken with a curved needle through the tissues underneath it, in order to control the hemorrhage. Mural fibroids have also been removed by the internal route, by dilating the cervix, splitting the mucous membrane, and shelling out the tumor with the finger or with a serrated spoon. The hemorrhage is apt to be free, but can usually be controlled by a tampon. Tumors of considerable size, however, have been removed through the vagina by morcellement, cutting away small pieces at a time, controlling the hemorrhage meanwhile by the pressure of sponges on handles, or by clamps. It is necessary to detach the cervix from the vagina by a circular incision and then split it on both sides in order to gain access to the cavity for this proceeding. The uterus can be drawn down by volsella set in the lips of the cervix, and tumors removed from the fundus as described. The cavity is then firmly packed and the cervix restored by sutures. *Abdominal myomectomy* is performed by laparotomy through a median incision, the uterus being brought outside the abdomen and the wound temporarily closed. An elastic band should not be applied, because of the danger of thrombosis and embolism. Pedunculated tumors are treated by a wedge-shaped excision of the base of the pedicle, hemorrhage being controlled by ligatures or deep sutures. Interstitial tumors require an incision through the uterine tissue down to their capsule, and they can then be shelled out. Ligatures and deep sutures arrest the bleeding. Sometimes the uterine canal is opened during the operation (hence it should always be given a preliminary curetting), but it can be closed by sutures. If there are many tumors, a number of incisions will be needed for their removal. After the myomectomy the uterus is replaced and the laparotomy wound closed as usual.

Hysterectomy.—*Vaginal hysterectomy* can be employed for fibroids, but is seldom indicated, although recently even large tumors have been removed in this manner, being cut away by morcellement after ligation of the uterine arteries. *Abdominal hysterectomy*, however, is the operation most frequently performed. The usual antiseptic precautions are to be taken, and the uterus should be thoroughly curetted before the abdomen is opened, and gauze packing inserted in the uterus and vagina. The operation may be done by a long median incision, the length of which should be in proportion to the size of the tumor. The patient is put in the Trendelenburg position, the tumor brought into the incision, and sponges packed around it to hold back the intestines. The operator begins at one side by tying

off the ovarian artery at the edge of the broad ligament, either applying double ligatures, or applying a ligature on the proximal side and a forceps on the distal or tumor side, and cutting between them. A series of ligatures is thus passed down to the base of the broad ligament, which is divided step by step as the ligatures are placed. The proximal ligatures must interlock or at least overlap in the tissues which they include, so that there is no possibility of any vessel being left untied between them. The vessels of these large fibroids are very large and the veins very thin-walled, so that hemorrhage is apt to be free, and the aneurism-needle not infrequently passes through one of the veins. Having freed the tumor upon one side, the operator treats the other in a similar way, and finally reaches and secures the uterine arteries. In this last ligature care must be taken not to include the ureter. The peritoneum should then be divided across the front of the tumor, and the bladder dissected off bluntly and pushed downward; the peritoneum is also incised on the posterior surface and stripped downward so as freely to separate the rectum. In this manner the upper part of the vagina becomes accessible; the vaginal portion of the uterus is easily recognized by the touch, and the vault of the vagina can be opened with scissors at its junction with the cervix. A number of small vessels bleed in this incision, and should be caught with clamps. The tumor and uterus are then taken away. The vaginal opening is closed by sutures; the edges of the divided peritoneum are brought together and sutured, all ligatures having been cut close, and the peritoneal cavity is thus shut off from the raw surfaces. The abdominal wound is closed in the usual way, and a light packing put in the vagina. If there is much oozing, or if infection is feared, a gauze packing may be left in place under the peritoneum and its end brought out of the vagina, which is not sutured. The after-treatment of these cases is that of the ordinary laparotomy.

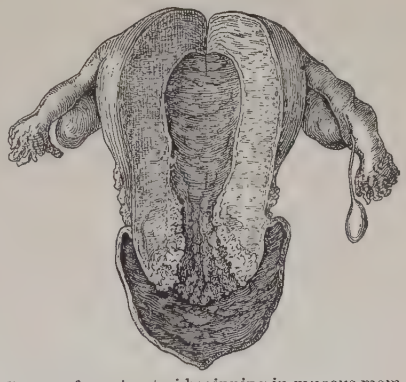
Formerly a portion of the cervix was left, being secured in the abdominal wound by clamps or needles passed through it, or the centre being excised in a wedge-shaped manner, and the two flaps of the uterine tissue brought together and sewed in place. This operation is now seldom used, but it may be employed when it is not easy to reach the vagina, and differs in no other respect from the operation described. Kelly has suggested enucleating the fibroid by splitting the edge of the broad ligament, detaching the peritoneum from the vessels, and ligating them in the loose cellular tissue as the operator proceeds downward towards the cervix. When the latter has been reached it is divided, the tumor and the uterus are rolled upward out of their bed, and the uterine artery of the other side is then secured with its branches, working upward, and tying the ovarian artery of that side last. The operation should be begun upon the side where the cervix is most accessible. This method is the easiest one by which to attack extraperitoneal growths, and, although it requires more skill, it undoubtedly leaves the peritoneal surfaces in better condition. If the tumor has grown extraperitoneally between the folds of the broad ligament the difficulties of removal are much greater. The large vessels run irregularly in the connective tissue to the tumor, and there is more danger of injuring or occluding the ureter in a ligature, as it may be displaced by the downward growth of the tumor. In

such cases the peritoneum should be incised high up near the fundus of the tumor, the latter shelled out, and the operation completed extraperitoneally in a manner similar to Kelly's. In any case it is of great assistance to have a bougie introduced into each ureter by Kelly's method of cystoscopy before the laparotomy is begun, for injury to these ducts is one of the chief dangers of the operation.

Malignant Tumors.—Both sarcoma and carcinoma are found in the uterus. **Sarcoma** occurs between thirty and fifty years of age, developing in the submucous tissue or in the uterine wall and forming tumors of considerable size, often pedunculated, which bleed very readily, and are rather soft to the touch, although some of these tumors originate from fibromyoma and are hard. Sarcoma is more frequent in the body than in the cervix. The first symptom is profuse hemorrhage, and it is only when the tumor has reached a considerable size that the pain is troublesome. The diagnosis can seldom be made sufficiently early for a radical cure, but the uterus should be extirpated whenever it is movable and the disease appears to be limited to the organ. It is impossible to distinguish between sarcoma and carcinoma except by the microscope.

Carcinoma of the uterus is found most commonly in the cervix as an ordinary tubular carcinoma originating in the mucous glands, and more rarely as an epithelioma from the flat epithelium on the surface of the vaginal portion. Scirrhus is very rare in the uterus. Epithelioma begins as a superficial, flat induration, which soon forms an ulcer and spreads over the cervix, the latter often being entirely destroyed before its presence is appreciated. The surface of the ulcer is covered with brittle granulations, which break down easily under the finger and bleed profusely. The ordinary carcinoma develops in the interior of the cervix (Fig. 914) or at the fundus, and forms rather large tumors, often protruding from the cervix in a cauliflower growth, but sometimes remaining entirely within the organ and simply distending it. As the disease progresses it involves the entire organ, attacks the vagina, penetrates the vesical and rectal septa, and sometimes attacks adherent coils of intestine. Glandular infection occurs very early. Metastatic deposits are rare, but are more frequently found in the liver and lungs in such cases than elsewhere.

Fig. 914.



Cancer of cervix uteri beginning in mucous membrane. (Boldt.)

Symptoms.—The symptoms of carcinoma of the uterus are a more or less constant discharge of a foul-smelling watery fluid slightly tinged with red, and slight hemorrhages occurring at irregular intervals and often following sexual intercourse. The hemorrhages usually do not occur until late in cancer of the cervix, but are an early symptom in that of the corpus. Hemorrhages after the menopause has been duly established are almost in-

variably due to malignant disease. When ulceration has once set in, the discharge becomes exceedingly offensive, with a peculiar acrid odor. In the later stages the sufferings of the patient are intense, and may be uncontrollable by large doses of morphine; but in the early stages pain is usually absent, for it is not caused by the disease in the uterus, but by the secondary pelvic deposits. The tumor often runs an extremely latent course, and the patient is unaware of its existence, and may even consider herself in perfect health, until some slight discharge attracts her attention and an examination reveals advanced malignant disease.

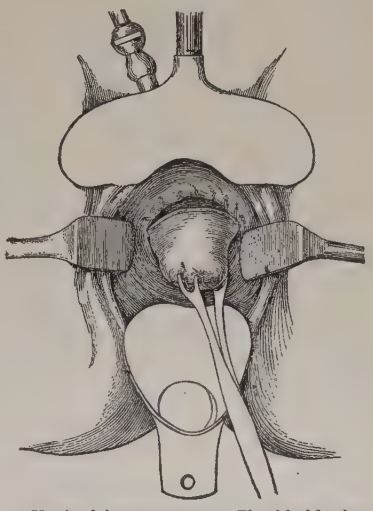
Diagnosis.—**Cystic degeneration of Naboth's glands** sometimes forms a hard nodular tumor in the vaginal portion, but the mucous membrane is smooth, the translucent cysts appear at various points, and ulceration does not take place. **Venereal warts** may make a considerable tumor, but their base is not indurated, they are not brittle, and there is no true ulceration. **Erosions** often surround the os uteri, but they have a graduated margin, and usually a soft base, without true ulceration. **Tuberculous ulcers** are rare; they are not so indurated, and they often have undermined edges, and bases with yellow nodules. **Chancroids** should not occasion difficulty, but the primary lesion of **syphilis** may resemble malignant disease. Syphilis, however, will usually be found early in life, there will be lesions elsewhere, the induration is of a different character, and there will be a sloughing base instead of carcinomatous granulations. A carcinoma may distend the cervix so as to resemble an **interstitial fibroma** when no external ulceration has occurred. Carcinoma of the body may closely resemble **endometritis**, and even when the introduction of the sound or the finger detects flattened tumors or uneven places on the endometrium it is not certain that they may not be placental remains after abortion. On the other hand, the malignant changes in the endometrium may produce such slight alterations that they cannot be recognized by the finger. As a rule, the diagnosis of internal carcinoma of the uterus, except in the late stages, requires the microscopic examination of fragments obtained by a thorough curetting of the entire organ. In doubtful tumors or ulcers of the vaginal portion a piece of considerable size should be cut out of the suspected tissues and submitted to microscopic study.

Treatment.—**Contra-indications to Radical Operation.**—The best treatment for cancer is extirpation of the uterus, although high amputation of the cervix is perhaps sufficient when the disease is limited to that portion of the organ and is not extensive. A radical cure can be hoped for only when the disease is entirely limited to the uterus, as proved by the absence of indurated glands or cellular tissue in the pelvis, and by the fact that the uterus is freely movable, for the first symptom of extension of the disease is apt to be fixation of the organ. Immobility of the uterus caused by adhesions left from a former pelvic peritonitis should not be confounded with the fixation of malignant infiltration. By introducing two fingers into the rectum and the thumb into the vagina under anæsthesia (Winter), the very first signs of infiltration of the parametrium may be found as indurations close to the cervix. Inflammatory masses are usually larger than these indurations, and tumors formed by inflamed tubes and ovaries lie much higher

up, with the soft tissues in the broad ligament between them and the cervix and vagina. If the bladder appears unusually adherent, or the mucous membrane of the vagina is involved near it, the urethra should be dilated and the interior examined with the little finger. Involvement of the vagina is less important than that of the parametrium, as the former can be widely extirpated with a good result.

Vaginal Hysterectomy.—The usual method of removing a uterus with malignant disease is by the vagina. The patient is placed in the dorsal position, a perineal retractor is inserted, the cavity thoroughly curetted and packed with gauze, and a stout silk thread passed through the cervix. If healthy tissue can be reached, the cervix may be closed by two or three deep sutures. The operator incises the vagina at its junction with the anterior surface of the cervix and strips the bladder from the cervix by blunt dissection, inserting, if necessary, a sound into the bladder in order to determine the limits of the latter. The posterior fornix is opened in the same way, and the mucous membrane is incised upon the side of the cervix. When the patient is anæmic some blood may be saved by dividing the vaginal mucous membrane with the cautery, or by suturing the cut edge with an overhand suture as soon as it is divided. (Fig. 915.) Douglas's cul-de-sac is then opened, and under guidance of the finger a curved aneurism-needle or ligature-passer carries a stout silk ligature through the base of the broad ligament quite close to the uterus, which is then tied. This is repeated on the other side, and the tissues between the ligatures and the uterus are then cut with the scissors and the organ pulled farther down. By a series of three or four ligatures on each side all the tissues of the broad ligament are tied off, the ovaries and Fallopian tubes being drawn into the wound and their vessels included in the final ligature. Some surgeons prefer to invert the uterus and bring the fundus out into the vagina posteriorly, the cervix then passing up into the peritoneal cavity, after applying the lower ligatures, claiming that it is then easier to secure the upper part of the broad ligament. The uterus is then freed, and can be removed. The wound may be left open and lightly packed with gauze, or the peritoneal surface of the rectum and bladder united across the roof of the vagina. The ligatures are left long, and drop off into the vagina later. Some surgeons use clamps instead of ligatures, those on the proximal side being left *in situ* for two or three days, their handles, which project from the vagina, being wrapped in gauze. Much greater speed can be attained by the use of clamps than by the use of ligatures, but they are inconvenient. All danger of the ureters being included in the ligatures can be avoided by passing catheters into

Fig. 915.



Vaginal hysterectomy. The bladder has been separated from the uterus and the vaginal mucous membrane sutured. (Boldt.)

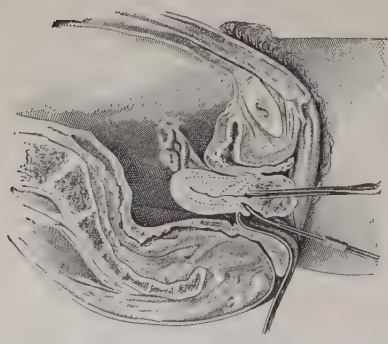
them by Kelly's method, in order to show their course and allow safe dissection.

Abdominal Hysterectomy.—In more advanced cases the uterus may be removed by an abdominal incision, which allows more extensive removal of the disease, but the operation is much more difficult. An abdominal incision is made from the pubes nearly to the umbilicus, the patient being in the Trendelenburg position, and catheters having been placed in the ureters. The ovarian artery is secured by a ligature at the edge of the broad ligament, the latter is cut across, and the uterine artery is then sought for, followed back to its origin, and ligated there. The bladder is separated from the uterus in front, and by the aid of the catheters in the ureters the latter are found and dissected out of the ligaments. The broad ligament is tied close to the iliac vessels and cut away. The other side is treated in the same way, and then the vagina is tied off by a series of ligatures and divided. In cutting away the broad ligament at the iliac vessels the lymphatic glands of that region should be removed (Clark). Polk ligates the anterior branch of the internal iliac, and claims that this gives a bloodless field of operation. The wound is closed as in the similar operation for fibroids.

Sacral Hysterectomy.—The uterus may also be removed by the sacral method, the pelvis being opened by partial resection of the sacrum, as in Kraske's resection of the rectum, or by Hochenegg's "trap-door" method. The advantage of this route is the free access it gives to the pelvic cellular tissue, especially posteriorly, which allows removal of infected glands. The operation is, however, difficult, and there are few cases in which it presents any advantage over vaginal hysterectomy.

Results of Hysterectomy for Cancer.—The results of these operations are now excellent, the mortality of the vaginal operation having come down to a very low figure, while the percentage of permanent cures is constantly increasing. Some authorities claim as much as fifty per cent., and it is certain that twenty-five per cent. of cures can be obtained without selection of favorable cases.

Fig. 916.



Amputation of cervix with cautery-knife. The dotted lines show the conical excision at various levels. (Boldt.)

Incurable Cases.—Extirpation should be strictly limited, however, to those cases in which there is a chance of radical cure, although the excessive hemorrhage and foul discharge of incurable cases may be lessened by a thorough curetting of the diseased parts. The thermo-cautery may be used to remove these tissues, or cauterization by chloride of zinc. The difficulty with the method of cauterization is that the limits of the operation are less easily defined and there is more risk of injuring the bladder and rectum.

High Amputation of the Cervix.—In epithelioma involving only the lower portion of the cervix and of small size, it is possible that high amputation of the cervix may effect a cure, and the operation is simpler than entire

removal of the organ. The first steps in the operation are similar to those described for vaginal extirpation, but when the level of the internal os is reached all that part of the uterus below it is removed with the scissors, the line of dissection being made conical, and reaching higher up at the level of the uterine canal than on the external surface of the organ. The entire operation may be performed without ligatures by the thermo-cautery-knife (Byrne). (Fig. 916.) This operation should be limited to the very mildest cases of superficial epithelioma seen very early, for it is as unreasonable to leave a part of a carcinomatous uterus as it would be to leave a part of a carcinomatous breast. The tumor shown in the cut is extensive and not suited for this operation, but the cut is intended to show the line of section and the relations of the bladder and rectum.

CÆSAREAN SECTION.

The Cæsarean section is the opening of the uterus through an abdominal incision at term in order to remove a child which cannot be delivered normally. The incision is made in the median line from the pubes to the umbilicus, and the uterus is brought out of the wound, the latter being partly closed by temporary sutures or clamps. Towels are laid around the uterus, and a rubber ligature is placed around the neck and the ends held by an assistant. The organ is incised in front in the middle line while another assistant compresses it laterally. The incision should be large enough to deliver the child, and may extend downward to the middle of the lower third of the uterus, but it should not open the cavity, being carried down only to the membranes at first. The placenta may be incised if it is in the way. The membranes are then opened, and the child delivered and handed to an assistant after clamping and dividing the cord. The placenta is then removed, and uterine contraction stimulated with hot towels or the faradic current directly applied by sterilized gauze electrodes, the rubber ligature being loosened at the same time. If contraction sets in, the wound may be closed by sutures, the first tier including the entire thickness of the uterine wall except the endometrium, and the second tier being passed as Lembert sutures. The abdominal wound is rapidly closed. If uterine contraction cannot be brought about, the uterus should be removed. Hysterectomy is also indicated when Cæsarean section is performed for the deformity of osteomalacia, because that disease improves after removal of the uterus. It is also advisable if septic infection is feared, and sometimes when the uterus is the seat of malignant disease. In cases of irremediable obstruction of the parturient canal by deformity or otherwise, the woman should be given the choice whether she will have the organ removed or run the chance of a subsequent impregnation. Oöphorectomy might also be considered in such cases. If hysterectomy is decided upon, it should be completed in the most rapid way, transfixing the pedicle with pins above the rubber ligature which is left in place, and securing it extraperitoneally in the lower angle of the wound. If the mother is in good condition, the intraperitoneal method may be employed, as in an operation for fibroids, or the edges of the stump may be inverted through the soft and dilatable cervix into the vagina after hemorrhage has been controlled by

ligating the ovarian arteries at the edge of the broad ligament and securing the uterine vessels by tying the anterior branches of the internal iliacs on both sides (Polk). The results of the Cæsarean operation are now excellent, only one-tenth of the mothers dying, and less than that number of the children.

DISEASES OF THE TUBES AND OVARIES.

Salpingitis.—The majority of the diseases of the Fallopian tubes are due to inflammations from gonorrhœal or septic infection, the latter occurring after labor, or from the introduction of septic instruments into the uterus. A purulent salpingitis may run a chronic course of a catarrhal type, simply thickening the walls of the tubes and causing the formation of adhesions about them, the tubes remaining patent and draining into the uterus, and a purulent endometritis being associated with the tubal disease. More commonly, however, the connection with the uterus is obstructed and the tube is distended by the accumulating purulent secretion. The open end of the tube at the fimbriated extremity is closed very early by adhesions, and the result is a pus-sac formed by the distended and usually convoluted walls of the tube which are firmly adherent to all the parts about it, and especially to the ovary—**pyosalpinx.** In milder cases the disease may not progress so far as to produce a pus-sac, but may cause obliteration of the uterine extremity of the tube, and then blood and serum may collect in the latter. In the former case we have **hæmatosalpinx,** in the latter **hydrosalpinx.** In connection with inflammation of the tubes, abscesses are occasionally found in the pelvis developing in the peritoneal cavity or in the cellular tissue, or involving the ovary. Occasionally these abscesses discharge externally beneath Poupart's ligament, or pass out through the obturator or sciatic foramen, but more frequently they burst into the vagina, the rectum, or the bladder.

Pyosalpinx.—Symptoms.—A patient with salpingitis, even of the mildest type, is liable to attacks of local peritonitis, especially at the time of the menstrual flow, and may have constant pain, increased by motion, sexual intercourse, micturition, and defecation, and sometimes shooting down the lower extremities owing to the pressure on the nerves. There may also be frequent micturition and constipation from pressure on the bladder and rectum, often associated with a slight septic condition, as shown by anæmia and an irregular rise of temperature. The temperature, however, is a very uncertain guide to the presence of pus in these cases, for even when there is a large amount of pus the temperature may be perfectly normal. There are various disturbances of menstruation, such as menorrhagia, dysmenorrhœa, and too frequent menstruation, or, if anæmia is present, the flow will be scanty and infrequent. Leucorrhœa is the rule, and pressure upon the appendages and uterus may cause a slight bloody, purulent discharge from the latter. The patient is generally but not invariably sterile. Pelvic examination shows the uterus more or less fixed, often retroverted, and pain is caused by attempts at motion. Indurated masses are felt on one or both sides and perhaps in Douglas's cul-de-sac, which are immovable and usually tender. All the pelvic organs may be fused into one mass, so that nothing can be distinguished, and the position of the uterus can be determined only by the passage of the sound.

Prognosis.—A mild salpingitis usually resolves, but adhesions are apt to remain and cripple the tubal and ovarian functions in some degree. Severe cases may end in a general peritonitis, abscess, or pyosalpinx, but more frequently they quiet down into the chronic form, which does not threaten life, although it renders the patients more or less invalids and subject to acute exacerbations from exposure to cold during menstruation, overwork, or too free indulgence in sexual intercourse.

Treatment.—Choice of Treatment.—The treatment of chronic salpingitis will depend upon the severity of the symptoms. Sometimes treatment directed to the accompanying endometritis will be sufficient. Operations should be limited to cases which prove obstinate under thorough general and local treatment, and the operations themselves should be as conservative as possible. A very acute salpingitis, with acute peritoneal infection, as shown by great tenderness and high temperature, should be treated by cold or hot applications externally, very hot vaginal douches, rest in bed, opium, and laxatives, and operation should be delayed until the acute symptoms have passed, for fear of exciting a general peritonitis by separating the adhesions. Should signs of general peritonitis or acute sepsis make their appearance, however, the surgeon will be forced to operate in spite of the danger of interference. The diagnosis of these cases from appendicitis may be very difficult. (See Appendicitis.)

Removal of the Tubes.—When pyosalpinx forms, extirpation of the affected tube and corresponding ovary is the best method of treatment, for, although attempts have been made to cure these cases by vaginal drainage, recurrences follow almost invariably. In cases of chronic catarrhal salpingitis marked by a thickening of the walls and adhesions, without the formation of a pus-sac, if the changes have not progressed too far a cure can sometimes be obtained by simply freeing the adhesions, but in advanced cases extirpation alone gives permanent relief.

The tubes and ovaries may be removed by a laparotomy in the median line, care being taken to pack back the intestines with pads or sponges, so that there can be no possibility of infection from the fluid which is likely to be discharged from the tubes by their rupture during the operation. The size of the laparotomy incision is immaterial; easy cases may be completed by an incision which will admit only two fingers, but the difficult ones may necessitate an opening extending nearly to the umbilicus, in order to deal with the complicated conditions with due regard to the safety of the patient. The Trendelenburg position is invaluable in difficult cases, but it is dangerous if large amounts of infectious fluid are evacuated, no matter how carefully the pelvis is surrounded by sponges. It is our custom to begin the separation of adhesions without it until we know how much fluid is likely to be found, and if, having raised the pelvis, we are surprised later in the operation by a sudden outburst of fluid, the pelvis is lowered at once. The irrigation also must not be undertaken until the pelvis has been lowered.

The surgeon first separates the adhesions around the affected tube, one ovary and tube usually being found in the cul-de-sac and the other higher up in the pelvis. The strength of the adhesions is tested, and those which

are not too strong are broken down with the fingers, but the strong adhesions must be divided with the scissors or knife under the guidance of the eye, for fear of injury to other parts. Bleeding vessels are secured by clamps and tied, and vascular adhesions may be tied before they are divided. The separation of the adhesions should be begun at the fundus of the uterus, if this can be found, and the finger gradually worked down to Douglas's cul-de-sac and then curved upward, following around the border of the mass. When the diseased tube and ovary have been freely separated they may be ligated *en masse*, like a tumor, the broad ligament and tube forming the pedicle and the ligature placed close to the uterus. The pedicle is then divided. It is preferable, however, to tie the ovarian vessels separately at the outer part of the broad ligament, and then the ovary can be partly detached and the size of the pedicle reduced. Some surgeons prefer not to ligate the tube itself, but to isolate it after tying the ovarian vessels and applying ligatures to all bleeding points, and then to divide the tube close to the uterus and cover in the stump with the broad ligament by sutures. When pus escapes from the tubes, and when the infection is recent and an active peritonitis is going on, irrigation and drainage must be employed. If pus escapes, it should be sponged out at once and the cavity irrigated.

Pyosalpinx tumors may also be removed by the vagina, the fingers being inserted through an incision into Douglas's cul-de-sac, the adhesions broken down, and the tubes and ovaries brought into the vagina, where they are ligated and cut away. In very bad cases vaginal hysterectomy is wise, and the uterus should be removed first, when the tubes will be more easily reached. The uterus may be found high up and difficult of access, and in such cases it is removed by morcellement, clamping the lateral attachments as the organ is cut away. Removal of the uterus, however, should be limited to the very severest cases of pyosalpinx, with complete functional destruction of the pelvic organs, as cures can undoubtedly be obtained without resorting to that extreme measure in ordinary cases. It should be noted that it is generally wise to remove the tubes and ovaries on both sides, even if one appears tolerably healthy at the time of operation, as it very frequently becomes diseased at a later period.

Hæmatosalpinx. Hydrosalpinx.—This form of disease is generally unilateral, and occurs in young women. The **symptoms** of hæmatosalpinx and hydrosalpinx are those of a tumor in the pelvis, pressing upon the surrounding organs, displacing the uterus, and sometimes causing pain by the tension of the sac at the menstrual period. **Treatment.**—A cure may be obtained by simple drainage of the sac after suturing it to the abdominal wall; but this results in a fistula with an annoying discharge of blood at the menses, and complete removal of the tube is preferable.

Ovarian Abscess.—Inflammation of the ovary resulting in abscess is usually found in connection with salpingitis, but in rare cases it occurs independently. In the latter cases a tumor is found upon one side of the uterus, usually globular in shape, with a fairly distinct outline, and there is a previous history of pain in the back and pelvic distress, with the symptoms of pressure upon the bladder or rectum. A rise of temperature may be found in these cases. The treatment is similar to that for pyosalpinx.

Tumors of the Ovary.—**Pathology.**—Tumors of the ovary are most frequently cystic, and their origin can best be understood by reference to the accompanying diagram of Doran. (Fig. 917.) They may arise from the oöphoron, as the active part of the ovary is termed, or from the paroöphoron, as the hilum is called. With the ovarian tumors are to be considered tumors arising from the parovarium, and in the broad ligament independent of that organ. The practically important tumors of the ovary are as follows: (1) **Follicular Cysts.**—The simplest form of ovarian cyst is the dilated Graafian follicle. These tumors are unilocular, and contain a single cavity, with very thin walls, filled with serous fluid. They are of small size, rarely reaching the size of an English walnut, and of no clinical significance. When associated with hydrosalpinx the distended tube may become agglutinated to the ovary, and the cyst in the latter may connect with the cavity of the distended tube, a condition known as a tubo-ovarian cyst. (2) **Multilocular Cysts.**—The larger cysts of the oöphoron do not develop from these small cysts, but originate independently from the germinal epithelium, forming multilocular cysts, which may attain an immense size, furnishing the largest of these tumors. (Fig. 918.) The wall of these cysts is white, but where it is very thin it allows the dark-green or brown color of the contents to shine through. These cysts grow first upon one side, but assume the median position as they rise out of the true pelvis, and may extend up to the ensiform cartilage and contain many quarts of fluid. They are found at any period of life. (3) **Cysts of the Paroöphoron.**—Cysts with papillomatous growths on the interior surface of their wall have a single cavity and originate from the remains of the parovarium in the hilum of the ovary. (Fig. 919.) The cysts grow in the substance of the broad ligament,

Fig. 917.

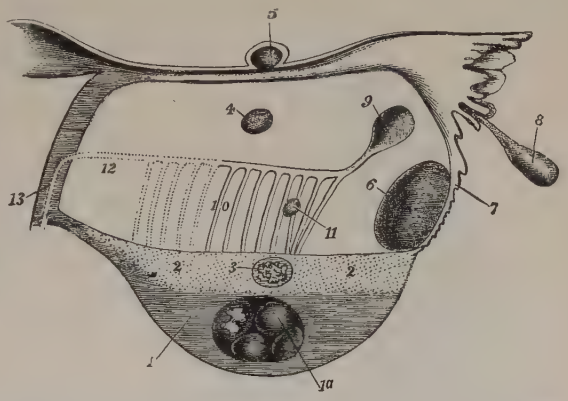
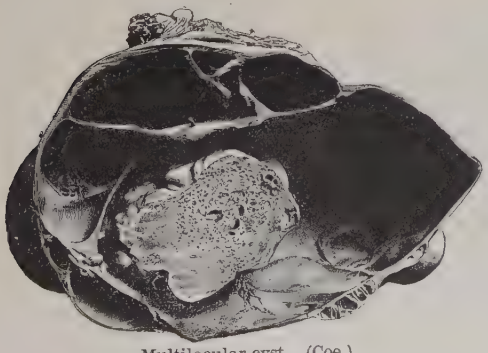


Diagram showing the origin of tumors of the ovary and broad ligament: *1*, parenchyma of ovary; *1a*, glandular multilocular cyst; *2*, hilum; *3*, papillomatous cyst; *4*, cyst of broad ligament; *5*, similar cyst above and not connected with Fallopian tube; *6*, similar cyst close to *7*, ovarian fimbria of tube; *8*, hydatid of Morgagni; *9*, cyst from horizontal tube of *10*, parovarium; *11*, cyst from vertical tube of same; *12*, duct of Gärtner, traversing uterine wall at *13*. (Doran.)

Fig. 918.



Multilocular cyst. (Coe.)

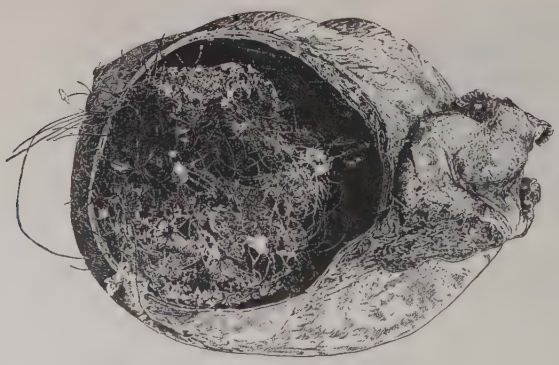
and can hardly be distinguished from cysts of the parovarium itself. These cysts are usually bilateral.

(4) **Parovarian Cysts.**—The parovarian cysts are unilocular, and are filled with clear serum or contain papillomatous growths. They may attain a large size. They are easily shelled out of the ligament, and the Fallopian tube is found on the upper surface of the ovary at one side. They usually come to operation between the sixteenth and twenty-fifth year of the patient's age. The papillomatous growths of both varieties of proliferating cysts may perforate the capsule, and small portions may be transplanted, being carried into different parts of the peritoneum, where they become fixed and grow. They even invade the blood-vessels, and are transferred to distant parts of the body, giving rise to metastatic growths in the lungs. True malignant degeneration is also frequent in these tumors, an irregular epithelial growth beginning in the papillomatous parts and involving the entire cyst, or only a portion of it. In such cases it acquires all the characteristics of carcinoma. Adenomatous growth is also frequent in the papillomatous cysts, an overgrowth of the contained epithelium producing a structure more nearly resembling a normal ovary. (5) **Dermoid cysts** (Fig. 920) are common in the ovary, and it is as yet uncertain whether they are due to the turning in of epithelial structures from the surface of the body, as in the case of dermoid cysts in other situations, or arise from the ovarian cells themselves on account of their high pro-

Fig. 919.

Papillomatous ovarian cyst. (Coe.)

Fig. 920.



Dermoid cyst. (Coe.)

ductive power. One reason for holding the latter view is the great variety of tissues which are found in these tumors as contrasted with dermoid cysts found in other parts of the body.

(6) **Solid tumors of the ovary** may be benign, such as fibroma or adenoma. More rarely warty growths are found covering the external surface of the organ. (Fig. 921.) Sarcoma and carcinoma are not uncommon; epithelioma is also found. These tumors rarely attain a large size, seldom being six inches in diameter. Usually they are globular, with a rather smooth surface. **Solid tumors of the broad ligaments** occur rarely. Myofibroma, developing from the unstriped muscular fibres of the ligaments, and lipoma are found. Secondary malignant growths are common in the broad ligament, developing from the lymphatics in the neighborhood.

Fig. 921.

Papilloma of ovary. (Cleveland.)

Course.—Tumors growing from the ovary usually develop from its free surface and extend directly into the peritoneal cavity, but they may enlarge in the opposite direction between the folds of the broad ligament, and thus become almost entirely extraperitoneal tumors. The parovarian cysts develop between the folds of the broad ligament, the peritoneum over them usually not being adherent; but the ovarian cysts which develop from the hilum may also penetrate the broad ligament. As the tumor grows upward in the peritoneal cavity it presses upon different organs, and forms adhesions with them or with the parietal peritoneum. Occasionally, however, the tumor does not form adhesions, even when it is of large size and long duration. When both ovaries are cystic the two cysts may become adherent, and an opening may form between their cavities, so that the cyst will appear to be a single cyst with two pedicles. As the tumor grows outward towards the peritoneal cavity the hilum of the ovary is not much altered, and as the vessels enter the tumor through the hilum the latter forms the pedicle. The pedicle varies in size and shape, usually being somewhat flattened, and a couple of inches in breadth by half an inch in thickness; but in some cases it becomes immensely elongated, and the tumor may be rotated upon its pedicle, the latter being twisted so severely as to cut off the circulation and cause gangrene. The symptoms of this condition resemble those of acute peritonitis or intestinal obstruction, the patient falling into a condition of shock, with subnormal temperature, vomiting, which may become fecal, and absolute constipation, with great abdominal pain. Occasionally the pedicle gives way entirely, but in the majority of cases the tumor has

already formed strong adhesions to the parietal peritoneum or to the viscera, and its vitality is preserved by the vessels derived from those sources. Cysts may therefore be found attached only to the upper part of the abdomen which really had their origin in the pelvis, but have lost all trace of connection with that part. An ovarian cyst may become infected and suppurate, the infection probably taking place through an adherent loop of bowel. In such an event the symptoms are those of an acute abscess, which may burst either externally or, more commonly, into some of the hollow organs. A cure may result under these circumstances, although it is rare.

Symptoms.—The symptoms of ovarian and broad ligament tumors depend upon their size, consistency, and situation. The tumors are unnoticed until they attain a considerable size, unless they are accidentally discovered by the physician in a pelvic examination. When small they excite very few symptoms unless they become impacted in the lower part of the pelvis and displace the uterus or press upon other organs. The solid tumors are more likely to occasion symptoms, even when they are of small size, owing to their greater weight and consistency and their tendency to develop downward and under the peritoneum rather than to grow upward. When the tumor is large it interferes with the functions of the abdominal viscera, and the patient becomes cachectic and anæmic, the face assuming a peculiar, anxious expression in advanced cases. The cyst may be so large as to embarrass respiration, and the interference with digestion may be so great that the patient is reduced to extreme emaciation. While ovarian cysts are most common in early adult life, they may be found at any time from infancy to old age. Their presence does not always prevent pregnancy or interfere with its completion, and, as a healthy Graafian follicle has been seen in the walls of such cysts, pregnancy is possible even when both ovaries are cystic. The cysts are frequently bilateral, but, as a rule, one ovary is fairly healthy. The menstrual function is usually unaltered, although some tumors cause menorrhagia, and the menses gradually cease as the cachexia develops.

Diagnosis.—Physical Examination.—An ovarian tumor while it is small usually lies in Douglas's cul-de-sac, is frequently movable, and is hard or cystic to the touch according as it is solid or fluid, the dermoid cysts having a peculiar doughy consistency. It is difficult in this stage to demonstrate the attachment of the tumor to the uterus, but it is usually possible to determine which is the diseased ovary by the detection of the normal ovary and tube upon the other side. The uterus will be felt in front of the tumor or slightly to one side. The fingers can usually be passed between the fundus of the uterus and the tumor, unless the latter has developed in the folds of the broad ligament and gained its position behind the uterus by stripping up the peritoneum from that organ, in which case it will be impossible to execute this manœuvre. Tumors of the broad ligament fix the uterus completely and displace it towards the opposite side. The diagnosis of tumors of this kind from subperitoneal fibroid tumors of the uterus may be very difficult, and they may also be mistaken for the retroflexed pregnant uterus. As the tumor enlarges, it rises out of the pelvis, and at this stage its connection to one horn of the uterus by a pedicle can generally be demonstrated,

especially if the uterus is well drawn down by an assistant with a volsellum fixed in the cervix, and the examiner passes two fingers of one hand into the rectum and presses above the pubes with the other hand while another assistant makes upward traction on the tumor through the abdominal wall. The diagnosis from fibroid tumors may be made by the introduction of the uterine sound or by feeling the round ligaments or tubes upon the side of the tumor.

When the tumor attains a large size, which will occur only in the cystic tumors, it may fill the entire abdomen and resemble ascites, but the diagnosis may be made as has been explained in speaking of tumors of the abdomen. In ovarian tumors there will be dulness from the pubes upward towards the navel in the median line of the abdomen, or somewhat to one side, while the flanks will be resonant. In ascites, on the other hand, there is dulness in the flanks, and the central part of the abdomen is resonant usually well down towards the pubes. The areas of dulness may be altered in both cases by changes in the position of the patient, but will be much more marked in ascites than in the cyst. The tumor is in contact with the abdominal wall in front, bowel very rarely intervening. Fluctuation may be obtained in these large cysts, and usually the cyst outline can be made out, although if the cyst is not very tense and is thin-walled these tests may be impossible. True ovarian cysts, as a rule, have a thick wall, and may be lobulated or vary in consistency in different parts, as may be appreciated upon palpation, while cysts of the broad ligament are generally globular and thin-walled. In the large tumors it is usually impossible to demonstrate the existence of the pedicle which attaches them to the uterus. With ovarian cysts the uterus is generally low down, whereas with uterine fibroids it is drawn up and elongated. The most confusing cases are those in which there is ascites encapsulated by adhesions, or in which an ovarian cyst of large size is complicated with ascites, and often in the latter case the diagnosis can be made only by drawing off the free fluid, when the cyst can generally be demonstrated. For the diagnosis from fibroids of the uterus, see that section.

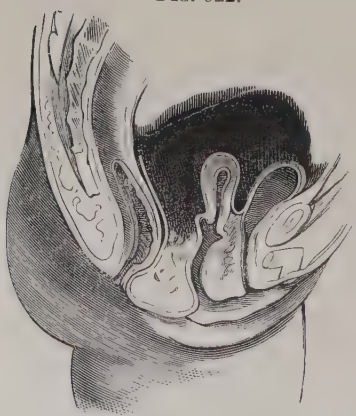
Treatment.—The best treatment for tumors of the ovary or of the broad ligament is removal by operation, for aspiration followed by the injection of irritating fluids, tried in old times, is too dangerous a procedure. The removal of an ovarian cyst is commonly known as **ovariotomy.** To remove an ovarian cyst a median abdominal incision is made just above the pubes large enough to insert three or four fingers. A sound is swept around the tumor to ascertain if there are any adhesions, and if none are found a trocar is plunged into the cyst, the patient having been turned on one side so that any escaping fluid shall not enter the peritoneal cavity. As the cyst collapses the flaccid walls are seized with forceps near the point of insertion of the trocar and drawn out of the abdominal wound, the entire cyst being gradually pulled out until nothing remains but the pedicle. This is tied off in the usual way by transfixing it with a double ligature of heavy silk, the loops of which should intersect, and the knots should be tied on the thin edges of the flat pedicle. The pedicle is then divided on the distal side of the ligature, and the abdomen closed in the usual way. If adhe-

sions are found, and they are not extensive, the procedure may be the same, the adhesions being separated as the cyst is drawn out of the abdomen by careful sponging, or by dividing them between two ligatures. If extensive adhesions are found, however, the incision should be enlarged, and the adhesions separated freely before the sac is punctured by the trocar, so that the operation can be abandoned with safety if it is found that the adhesions are too serious to permit removal of the tumor. If the bowel is too adherent to the sac to allow of separation, the adherent loop may be resected and the two ends united by Murphy's button or by sutures. If several loops are adherent, it will be best to abandon the operation. If the large intestine is resected for adhesions, the ends may be sutured, or they may be included in the abdominal wound and an artificial anus established which can be remedied later. The adhesions which are most frequent and easiest to deal with are those to the omentum, for they are readily tied off. Adhesions to the parietal peritoneum may compel the sacrifice of a portion of that membrane. When the adhesions are extensive there is usually considerable oozing from the raw surfaces left by their separation, and it is best to drain after operations in such cases. Occasionally it will be necessary to leave portions of the cyst adherent at various points, in which case their epithelial surfaces should be thoroughly removed by the curette or the cautery.

PELVIC HÆMATOCELE.

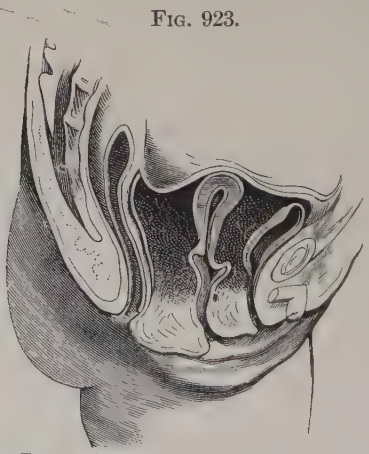
Pelvic hæmatocele is a collection of blood in the pelvis, either external to the peritoneum or within its cavity. **Intraperitoneal hæmatocele** (Fig. 922) usually derives its blood from the Fallopian tubes in menstruation, although it may come from a vessel in a ruptured Graafian follicle or from ruptured adhesions in **hemorrhagic peritonitis**, a form of peritonitis similar to pachymeningitis hæmorrhagica, with many new thin-walled

Fig. 922.



Intraperitoneal hæmatocele. (Agnew.)

Fig. 923.



Extraperitoneal hæmatocele. (Agnew.)

blood-vessels. **Extraperitoneal hæmatocele** (Fig. 923) may be caused by the rupture of a vein in the cellular tissue. These hemorrhages are most frequent in young women, and are apt to occur during menstruation. Hæmatocele is not a very common condition, and probably many of the

cases formerly classed under this head were really instances of very early extra-uterine pregnancy. The hemorrhage usually takes place at menstruation, which then ceases, although an irregular flow from the uterus may continue in its place. The patient feels severe pain in the pelvis, and there are usually signs of peritoneal irritation, in some cases amounting to a true peritonitis. There is abdominal tenderness, with a feeling of distention, and some tympanites. Examination shows nothing at first, the blood being fluid, but after the blood has coagulated a doughy mass becomes evident in Douglas's cul-de-sac or on one side of the uterus in the broad ligament. The blood-clot is usually absorbed in a few days, and the symptoms subside unless infection takes place, when an abscess may form and require surgical interference. The symptoms of a suppurating hæmatocele are similar to those of pelvic abscess in general, and the treatment should be the same, the pus being discharged by an incision into Douglas's cul-de-sac or into the cavity of the broad ligament.

EXTRA-UTERINE PREGNANCY.

The ovum occasionally becomes impregnated while yet in the ovary, or in the abdominal cavity or the Fallopian tube during its passage towards the uterus, and may develop in any of these situations. It almost invariably develops in the Fallopian tube, but may make its way later into the peritoneal cavity or between the folds of the broad ligament by rupture of the sac. In the broad ligament the fœtus usually dies, and the resulting hæmatocele becomes absorbed. In the peritoneal cavity, however, the fœtus may continue to live, and even if it should die the sac may still further enlarge by persistent hemorrhage. If the fœtus dies after considerable development, the tumor may persist indefinitely as a cyst containing the mummified fœtus, or it may suppurate or ulcerate into some of the hollow organs or through the abdominal walls, and thus discharge the body of the fœtus and other contents. The cause of ectopic pregnancy is generally a stricture of the tubes due to some antecedent inflammation which obstructs the outward passage of the ovum; hence it is most commonly seen after a long period of sterility.

Symptoms.—The symptoms of an extra-uterine pregnancy may be so vague as to be unnoticed by the patient. Usually, however, the menstrual flow is irregular, one or two periods being missed, with intermittent flowing in the interval, and a deciduous membrane may be expelled. The uterus is generally enlarged, and there may be signs of mammary development. There may be short, sharp attacks of pain in the pelvis and a feeling of weight and bearing down. The attacks of pain are to be ascribed to the rupture of adhesions or to the bursting of small blood-vessels about the sac. Extensive bleeding may occur, sufficient to cause syncope, and if the sac ruptures the symptoms will be those of severe shock from loss of blood, succeeded by a commencing peritonitis. As a rule, these accidents happen before the fœtus is three or four months old, but in some cases there is no rupture, and full development of the fœtus occurs, the woman believing herself naturally pregnant. The diagnosis is not easy, because the pain may be accompanied with fever, and the symptoms may closely resemble

appendicitis, renal colic, or inflammation due to gall-stones. There is no question that many cases of supposed simple hæmatocele are instances of extra-uterine pregnancy.

Treatment.—Successful attempts have been made to kill the fœtus by passing a strong faradic current through the sac, or by injecting morphine into the body of the fœtus. These methods, however, are uncertain and dangerous, for during the delay necessary to obtain evidence of the death of the fœtus the sac may continue to grow, and a fatal rupture may occur.

Operation at full term has succeeded in saving the mother, but, as a rule, in such cases it is well to wait until the fœtus dies and the parts have somewhat atrophied, so that their vascularity is reduced. If the diagnosis can be made in the early months, however, the sac should be removed by **early laparotomy**, and in cases of **rupture** with symptoms of hemorrhage not a moment should be lost. The statistics of operations for this condition have very much improved of late. The operation is begun by a median abdominal incision, the patient being in the Trendelenburg position. If the sac is very adherent or has developed in the broad ligament, it will be advisable to ligate the vessels passing to it from the pelvic wall and from the uterus before attempting to remove it. If the sac is entirely contained in the tube, the tumor may be treated like a pyosalpinx, being shelled out of its adhesions, the pedicle ligated, and the mass cut away. Intraligamentous sacs must be treated like ovarian cysts in the same situation. In advanced pregnancies the placental site may bleed freely after their removal, and the hemorrhage should be controlled by packing. Some surgeons advocate packing the wound and leaving the placenta to slough out later. In cases of collapse from loss of blood before the operation, no time should be spent in trying to establish reaction, because restoration of the pulse will only cause additional hemorrhage. The operation should be undertaken at once, and stimulants and saline injections or infusions given by an assistant while the surgeon attends to the laparotomy. In many cases old clots and fresh blood will be found filling the abdomen. These should be removed and the cavity thoroughly irrigated with hot sterile saline solution, the pelvis having been lowered. Drainage is necessary after these operations. The abdominal wound is closed in the usual manner.

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